NETWORKING AND COMMUNICATIONS

July/August 1991 Volume 9.4

Programmer Journal

.95 Canada $5.95

Spying on NetBIOS

page 45

Diving into the Modem Pool

page 36

Abrash on Edsun CFG/DAC Animation

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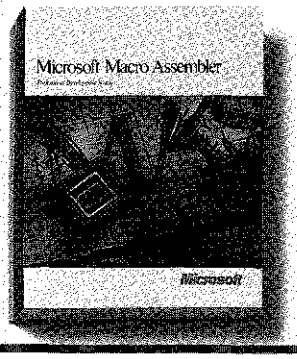

MICROSOFT SOFTWARE DEVELOPMENT TOOLS

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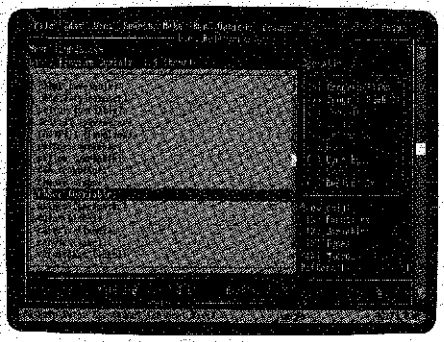

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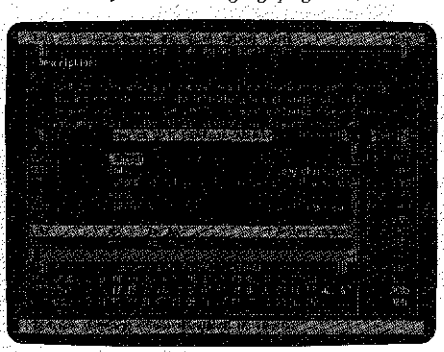

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New Features

- High-level language data types and control structures make mixed language programming easier. Including: PROTO/INVOKE, TYPEDEF, .IF/.THEN/.ELSE, and .REPEAT/.WHILE.
- Macro language extensions such as: @SubStr, @CatStr, @Date, & @Time.
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- Automated Jump shortening speeds execution.
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- User-defined Prologue/Epilogue customizeable for Windows.
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- Source Browser gives instant access to data declarations and function definitions.

PROGRAMMER'S TIPS

The new INVOKE statement automates procedure calling, by handling all pushing and popping of parameters on the stack. Example: INVOKE printf, ADDR fmt1st, ADDR str2, dat1, dat2

If you want MASM 5.1 compatibility, start with the MASM.EXE compatibility driver or use the /Zm switch with ML.EXE.

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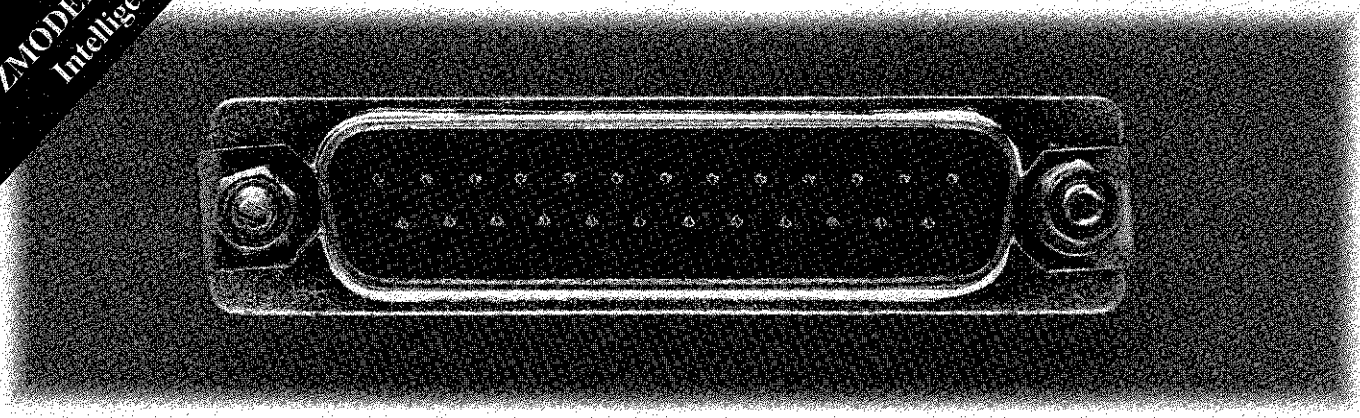

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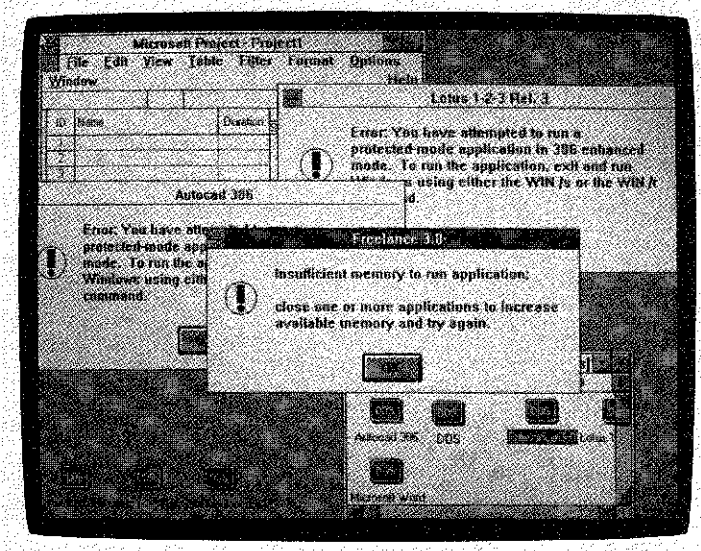
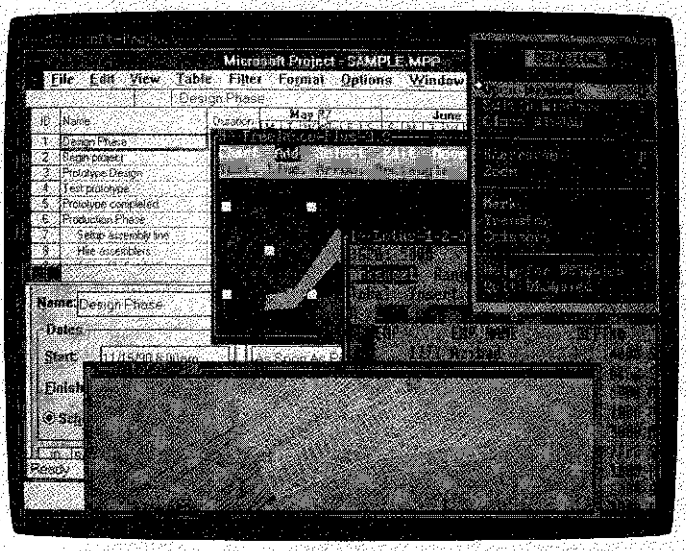
Is Windows 3.0 the end of DESQview™?

Not if you're still using DOS programs.


Microsoft Project - Project1
File Edit View Table Filter Format Options Window Help
Lotus 1-2-3 Rel. 3
Error: You have attempted to run a protected-mode application in 386 enhanced mode. To run the application, exit and run
Autocad 386
Freelance 3.0
Insufficient memory to run application.
Close one or more applications to increase available memory and try again.
OK
Autocad 386
DOS
Lotus
Microsoft Word

Windows 3.0. The multitasking, windowing environment.



DESQview 386 2.3. The multitasking, windowing environment.

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Whatever standard you use—DOS, extended DOS or Windows—DESQview is still the best way to get the most out of the hardware and software you own today.

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This comparison was made using a system like the one you might run: Both shots show an ALR FlexCache 33/386 running DOS 3.3 with VGA display adaptor, Novell NetWare v3.01 Rev. A, with IPX/SPX v3.01 Rev A, Microsoft Mouse 7.00, and Microsoft SMARTDrive v3.03 disk cache. Buffers were set to 20. For the Windows screen, we ran Microsoft Windows 3 HIMEM.SYS and EMM386.SYS. For the DESQview screen, we ran QEMM 386 v5.1.

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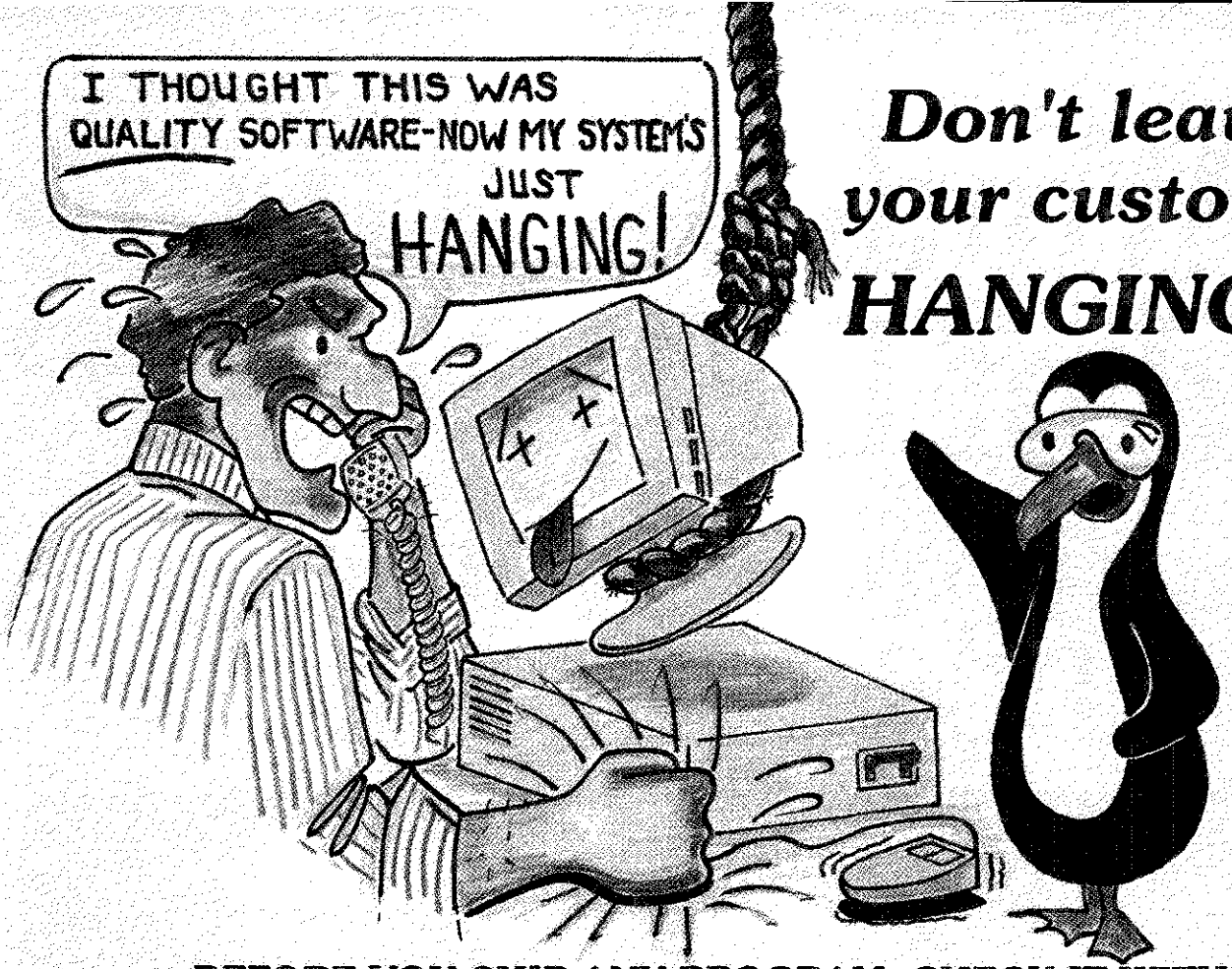

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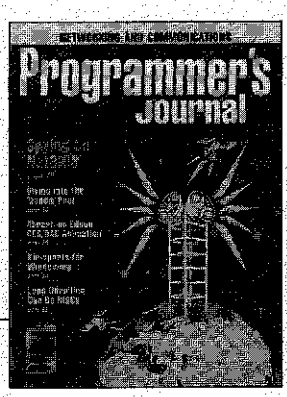

Hook up to a communications network, where the sky's no limit. Threads of wire and waves of wizardry connect the globe to our unfathomed future. For a look at what lies just beyond the horizon, join us in scouting out the possibilities explored in this issue. So plug in, power on, and find out what it's all about.

Cover Artist: Rob Schuster

FEATURES

GRAPHICS **24** **A COAT OF MANY COLORS** *By Michael Abrash*

Pick a pack of purple pixels . . . or make them red, white, and blue. Graphics guru Michael Abrash shows how to boost your screen's color quotient and program some animation using Edsun's plug-in DAC replacement, the CEG/DAC.

NETWORKING **36** **COMMUNICATING OVER NETBIOS** *By Brett Glass*

There's probably a modem pool in your future. Brett gets you into the swim of things by mixing communications with NetBIOS sessions and Turbo Pascal objects. He also looks briefly at not-so-standard network modem interfaces. So step into the LAN of plenty!

NETWORKING **45** **SPYING ON NETBIOS** *By John Otken*

Need to network your DOS machine with other computers? John develops assembly language routines to interface with NetBIOS and a utility for spying on datagrams. You'll also find his simple but elegant client and server applications for transferring files.

C **55** **WINDOW VIEWPORTS** *By Allen Holub*

Allen continues to perfect the art of window management in this second part of his text-windowing system. He tacks a display layer (or "viewport") on to the previous text buffer routines, creating a stand-alone windowing system that won't tie you or your computer's memory up in knots.

OPTIMIZATION **66** **LOOP UNROLLING: A RISCY BUSINESS** *By Mark J. Barrenechea*

Compiler optimizations tend to remain in the realm of the mysterious. Mark unravels loop unrolling to reveal its uses and discuss its limits. He also compares scalar and vector optimizations on the i860 with loop unrolling on the 80486.

ADA/C **73** **DATA STRUCTURE IMPERATIVES** *By Richard Riehle*

It's embarrassing when you don't know an algorithm from a biorhythm, or which data structure you need to get into the swing of things while traversing a binary tree. Richard poses challenging questions and provides some sample solutions.

BASIC **78** **TEXT FILTERS IN BASIC** *By Murray L. Lesser*

Who says simple can't be beautiful? Once you get to know Murray's text filter program, you'll want to write others—and you'll know how to go about it.

COLUMNS

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EDITOR'S NOTE

By the time you read this, I should be back swimming in the river. But for now it's cold and rainy here—an ideal time for working indoors with a collection of connected boxes. Although it may never be the "Year of the LAN," networks have become pervasive in the PC realm. The norm in large organizations, networks are filtering down to small businesses as surely as summer follows spring.

ALPHABET SOUP CAUSES NETWORK INDIGESTION

Problems remain with PC connectivity. In DOS, the battle continues between network drivers and applications for memory space, because network software isn't integrated with the operating system. So DOS memory managers are increasing in importance while OS/2 is on the back burner. Contrast this mayhem with the Unix world, where networking is a way of life.

Originally, most PC networks were homogeneous (everything was DOS); now, users are demanding interconnectivity with Macs, Unix boxes, and other machines. They're insisting on seamless, transparent connections, even though some PC protocols, such as NetBIOS, were not designed for internetworking. Also frustrating is the profusion of file-naming conventions and text-file formats. It's unfortunate that DOS designers didn't use Unix's "/" as a directory separator or support case in DOS file names. Macintosh system designers were equally shortsighted—they chose a different separator for directories, and a carriage return to indicate a text end-of-line.

Network protocols offer a large gulp of alphabet soup (aka acronyms). The International Standards Organization (ISO), academics, and the U.S. and European governments have endorsed the ISO "seven-layer cake" model. The PC and Unix marketplace favors well-tested non-ISO protocols, such as TCP/IP and SPX/IPX, that have fewer layers, take up less overhead, and perform better.

DOS EXTENDERS GO DPMI FOR TRANSPARENCY

Microsoft has quietly slipped a DOS extender into their C 6.0*x* package. They also have released Visual Basic and a Fortran update for Windows. Phar Lap and Ergo have introduced new Windows-compatible 286 DOS extenders. Phar Lap's extender supports OS/2-style function calls; other companies also have this OS/2-under-DOS technology. Rational, for example, has released Oxygen, a DOS extender for Microsoft C 6.0*x* tools that binds itself to the OS/2 executables for Microsoft C.

Ergo's DPMI 286 DOS extender allows you to build an executable that runs under Windows 3 as a DPMI client or under Ergo as a DPMI server. Other than Windows 3, Ergo's is the only DPMI server available. Interestingly, I was able to run the Phar Lap 286 DOS extender under Ergo.

Phar Lap has a new version of its 386 DOS extender that is not Windows—read DPMI—compatible and is testing another one that is. Ergo is finishing up a DPMI-compatible, 386 DOS-extender upgrade. Meanwhile, Intel has released its C Code Builder Kit. It's bundled with a DOS extender by IGC that is DPMI-compatible but won't work with EMS managers (not VCPI-compatible). A bit crazy, but soon the DOS-extender world will all be Windows-compatible.

BIG FELLAS HAVE BIG PROBLEMS

Large companies often dislike going "outside" for products or services. Take Microsoft's Excel-for-Windows group, which spends 11 hours doing a build with their Windows linker that takes about 10 minutes with SLR's Optlink/Windows.

As you've no doubt heard, Borland is working on a database competitor to Ashton-Tate's dBASE IV. Is Ashton-Tate—still reeling from the loss of dBASE language ownership—prepared for a direct-marketing onslaught from Borland? If you're wondering from whom Borland might purchase this technology, note that both they and Fox Software are indebted to the same venture capital firm. And of course, these new products will need to support interconnectivity. So will it be Borland-SQL or TurboBASE/LAN?

Steven Baker

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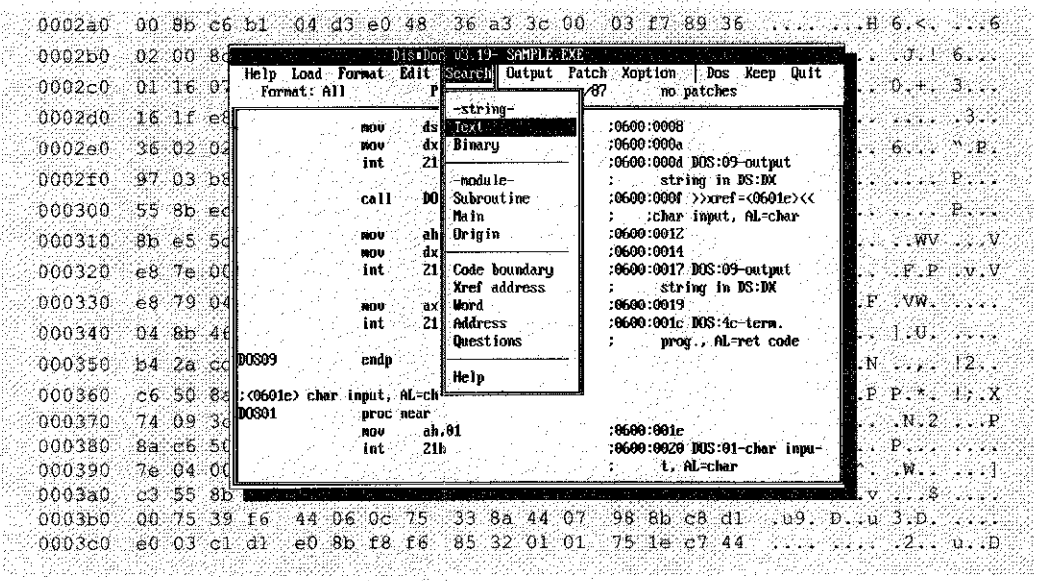

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LETTERS

PRODUCTIVITY OR BUST

I really enjoy your magazine and find it invaluable in my work. Thank you for a job well done.

I read William Roetzheim's "Programmer productivity" (*PJ* 9.3) with great interest. I brought the magazine to work, and the first reaction of a fellow programmer was, "Where does this guy live? California?" Sure enough, you listed the author's San Diego address.

I cannot imagine anyone here in western Pennsylvania calling a programmer who produces 2,000 lines of code per month a "guru" or "indispensable," let alone a "super programmer." And someone producing a mere 500 lines of code per month would hardly be considered "professional" here—more likely "unemployed." Yesterday I produced about 2,000 lines of code. I expect to get the same count today.

G. Adam Stanislav
East Pittsburgh, PA

After reading William H. Roetzheim's "Programmer productivity" (*PJ* 9.3), I became somewhat ill of mind and spirit. I find the author's "hammer them hard and

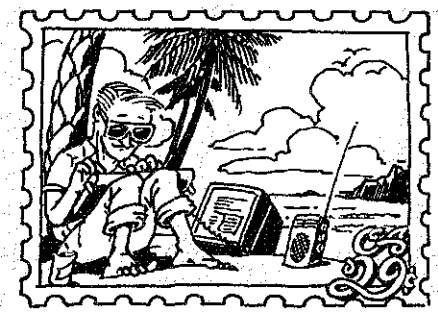

ILLUSTRATION BY JIM CARPENTER

fast" approach to confronting a programmer's honest repetitive errant behavior to be somewhat repugnant. I don't find the policy of managing people by fear and intimidation all that desirable, even if Roetzheim considers it to be more cost-effective in grooming a class of "Super Programmers." (I find that term as disturbing as his suggested methods.) Where's Marley's ghost when you need him?

Phil Pistone
Park Ridge, IL

BACK TO BASIC STRINGS

I read with interest Murray Lesser's article about string handling in BASIC PDS 7 (*PJ* 9.2), but he missed one useful feature of the **StringAddress** function. Not only does it return the address of the far string in registers DX:AX, but it also returns the length of the string in register CX. This makes calling **StringLength** unnecessary. When you consider that the new far string operations are much slower than the older near string operations, you will appreciate the reduced code and added speed in your ASM functions.

Daniel P. Stasinski
Willits, CA

A LODE OF WINDOWS

Paul Yao's interesting article on Windows compilers (*PJ* 9.2) was much appreciated. Inadvertently, however, he may have created the impression that these compilers are otherwise compatible, which isn't so. Borland's C++ 2.0 happily compiled the Windows parts of a little Microsoft C demonstration program I had, but it balked at Microsoft's **_dos_findfirst** function; Borland also uses **findfirst,** and the related data structure is different. The other compilers undoubtedly have similar variations for other-than-standard (i.e.,

AN OPEN LETTER TO SOFTWARE DEVELOPERS

Excessive litigation has been known to put doctors out of business. Now it's the programmer's turn. If you program professionally and develop commercial products that have any level of complexity, prepare to be sued. It is virtually impossible to write a software product without violating dozens of patents, and things are only going to get worse.

The League for Programming Freedom (LPF), a not-for-profit organization of programmers and users, is opposed to software patents. The LPF's position paper covers the wide range of issues regarding software patents (see address below). This paper documents numerous examples of ludicrous patents and of lawsuits—which have been upheld—that affect virtually every large software system.

Software algorithms should not be patented, any more than, say, chess moves. A clever chess move is not obvious, but any bright person faced with the board and some time could come up with it. The same principle is true for software algorithms—yet more than 2,600 software patents have been granted, 599 in 1990 alone.

You may come up with a dozen clever programming solutions in a day—every one of which may quite possibly already be patented. If this flawed system is not remedied, none of us will be able to do our jobs.

As a programmer who has been affected by the new rage of legal terrorism, I want to tell the personal side of the story. It revolves around the work I did to produce sound effects from within a computer game. There is only one way to make sound on an Apple II or an IBM: turn the speaker on, apply 5 volts, and turn the speaker off. The only thing you can vary is the rate at which the speaker is switched on and off. If you toggle the speaker very rapidly, it makes a quieter sound.

I wrote a trivial routine to do this, less than a couple dozen instructions total, and put it into a computer game. I have received two phone calls from two different companies putting me on notice that I may be violating their patents on this complex, high-technology technique covering "pulse-width modulation." So far I haven't been sued, but I've been asked to remove my product because it *might* violate their patent.

What's next? Threatening phone calls because I draw a cursor on the screen? (Patent #4,197,590 is being pursued vigorously by Cadtrak.) Or because I display and scroll some text in a couple of windows? (Patent #4,736,308—ask Apple, which was sued.) What if I optimize a routine that recalculates a table of numbers? (Ask Lotus, which is being sued by Refac Technology Development Corporation, a "technology" company with plenty of lawyers but no programmers or engineers.) Where will it stop?

Contact LPF at (617) 243-4091, or send Internet mail to league@prep.ai.mit.edu, or write to them at 1 Kendall Square #143, P.O. Box 9171, Cambridge, MA 02139.

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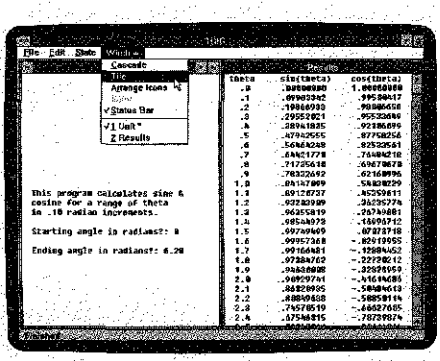

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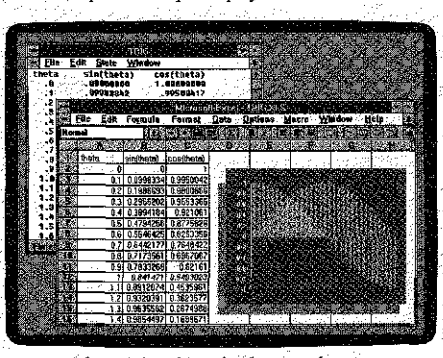

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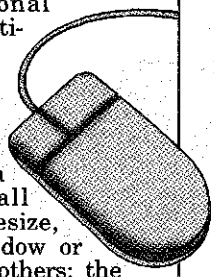

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not Unix-like) functions: the existing level of incompatibility among these products is not magically improved by Windows.

This, of course, only adds to the fun. As I've begun my first adventures in Windows, I'm developing a warm appreciation for Bill Gates's splendid "Programmers' Full Employment Project." I was planning alternate careers for my Golden Years, and just in time there comes this potentially lucrative *and* technically challenging gold mine!

J. G. Owen
Fort Salonga, NY

GUI, YES—GRAPHICS, NO

The March/April issue (*PJ* 9.2) was nearly perfect. Having once been a happy subscriber to *Micro Cornucopia*, I was delighted to see Dave Thompson in your pages. The articles by Thomas Lahey and Kim Kokkonen were particularly useful.

In "Porting to the Mac," I believe W. Sumerlin left out several useful books (and maybe a compiler). I once had to write a front end to FoxBase/Mac and wound up doing it in Turbo Pascal for the Mac. This is a terrific compiler, regrettably not much supported by Borland. Now that Apple has introduced machines resembling cheap Macs, maybe Borland will think again. My students are using Think Pascal 3.0, but for me Turbo is much less hassle, despite the lack of good debugging support. The most helpful books for learning Mac programming were Borland's own documentation for Turbo and the Turbo Tutor for the Mac. A close runner-up was Chernicoff's *Macintosh Revealed* series (volumes 1 and 2), essentially a humane rewrite of *Inside Macintosh*.

If Turbo Vision is a glimpse of things to come for Turbo Pascal for Windows, then Borland's C++ is probably the better choice. The idea of Turbo Vision is great, but it was obviously implemented by someone who was in love with LISP. I recommend that anyone pursuing text-based GUI invest the $100 or so in Kokkonen's Object Professional, and forget Turbo Vision. To be honest, I don't plan to run Windows before version 5, and certainly not on a machine with less than 586MB of RAM. GUI, yes; graphics, no—gimme DESQview. (By the way, how does a little Commodore 64–based software firm—Geoworks Ensemble—do a better job on a multitasking GUI than mighty Microsoft? Could it be the combination of a good assembler and talent vs. C and an army of drudges?)

David Derbes
Chicago, IL

DISASSEMBLERS DISCUSSED

This is in response to Brett Glass's "Disassembler roundup" (*PJ* 9.2). I usually do not write letters to the editor, but this article struck a nerve.

I agreed with the author on several points, but it is obvious from the author's opening and closing statements that he does not like disassemblers. Disassemblers are tools, not mysterious, forbidding, magical programs. Anyone can use them. They can be used to learn assembly language and to advance one's programming techniques and abilities, or to reconstruct lost source code or the code from unsupported programs. In short, disassemblers can be put to whatever use the *user* wishes. Disassembly is as much a science as any other programming activity. It is not a programmer's last resort or a quick and dirty cure-all.

Although Glass's article was, for the most part, factual, it missed the essence of the four programs he reviewed. It conveyed no feeling for how the programs worked or what they looked like. I would not go out and buy one, nor could I recommend that someone else buy one, based solely on the information in Glass's article.

If Brett Glass does not like disassemblers, then he should not write articles about them.

Mark M. Janecki
Gilroy, CA

I want to commend *Programmer's Journal* and author Brett Glass on the "Disassembler roundup." I realize that this article was not intended to be a thorough review of disassemblers, but I do have a couple of items that *PJ* readers might be interested in.

The first is the use of Glass's TORTURE.ASM program as a test case. Today's disassemblers are fairly smart at separating code from data—historically, their weakest point. Code sequences that do not fit the "normal" patterns are suspected of being data rather than code. When you feed a disassembler intentionally strange code (such as TORTURE.ASM), you may

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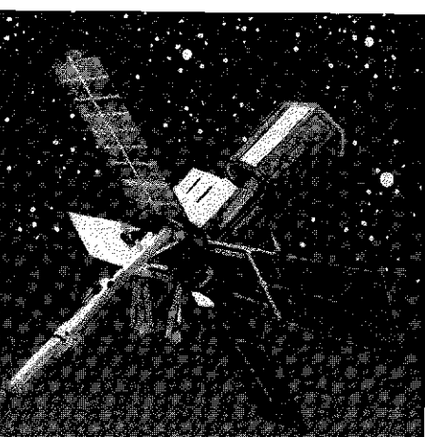

```
if (environ == critical) {
    survival = High_C;
```

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well find "incorrect" conversion of code to data and vice versa. Yet this is the proper result if the algorithms function correctly; disassemblers are designed to do their best jobs on the "normal," most common kinds of code.

A second—admittedly picky—point was the statement that MD86 did not "handle" addresses in segment:offset form. MD86 is very flexible in this regard, and almost any form of address input is acceptable. The manual (section 6.0) clearly spells this out. The user even has a choice of display formats.

Again, I wish to thank Brett Glass for taking the time to prepare this article. I hope we can look forward to a more in-depth review in the future. This subject has been kept in the dark too long.

Clark A. Calkins
Walnut Creek, CA

I use disassemblers as part of my job in writing very specialized compilers and have access to quite a few of these tools (far more than Brett Glass's review covered). Glass did not touch on some very important aspects.

I use disassemblers for two main reasons: to view code generated by compilers (mine and others) to find ways to improve its efficiency, and to obtain a program's source when it has not been provided. This implies being able to edit, reassemble, and *execute*.

Each disassembler has strong and weak points, and having more than one has definite advantages. However, the fact that disassemblers differ in their treatment of immediate values that are so common in code (such as MOV AX,1234) bothers me. Although the immediate value may look like an ordinary constant from the disassembler's perspective, it may actually be either a constant (such as a loop counter) or the address (offset) of a variable or procedure.

This small point is vital to successful execution if you plan to edit and reassemble the resulting assembly code—even though your code may appear to assemble and link just fine. As an example, consider the following small program:

```
     org    100h
begin: push   cs
       pop    ds
       mov    ah,2ah    ;get current month into
                         register "dh"
       int    21h
       mov    cx,12     ;look up month name in
                         table
       mov    si,offset months
lp:    dec    dh
       jz     gotit
lpl:   lodsb
```


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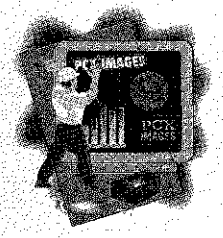

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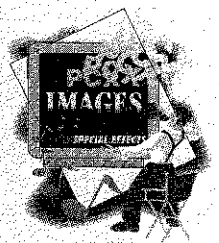

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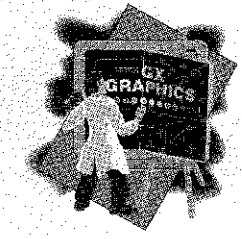

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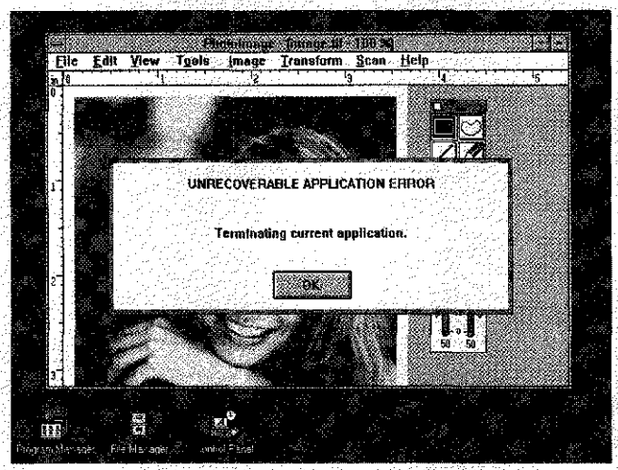

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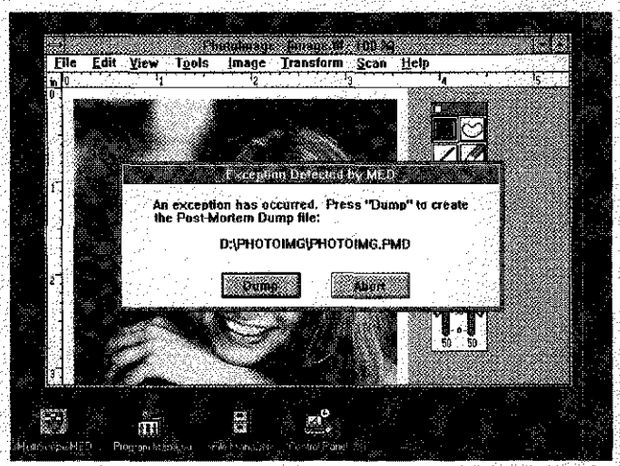
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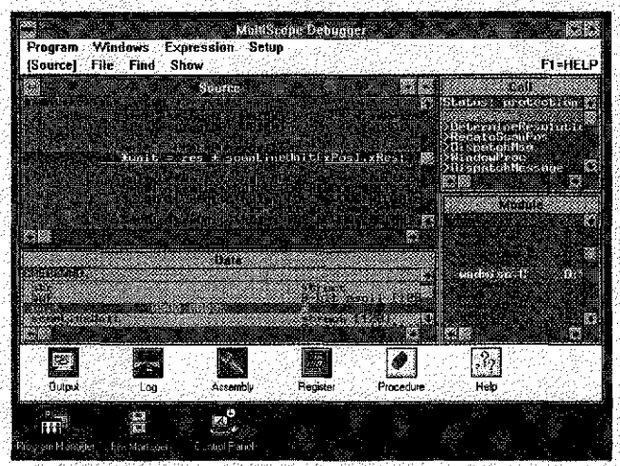
Abort



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```
        cmp     al,'$'
        jnz     lp1
        loop    lp
gotit:  mov     dx,si
        mov     ah,9      ;now display the month
        int     21h
        mov     ax,4c00h ;and exit
        int     21h
months:db       'January$'
        db      'February$'
        db      'March$'
        db      'April$'
        db      'May$'
        ..... etc.
        end     begin
```

I disassembled this with Sourcer, Dis•Doc, MasterKey, MD86, and Snoop. [Sample output is included on the code disk. —*Ed.*] I ran all programs as "automatically" as possible, with the least input from me. I could correct most "problems" by entering the proper instructions in every case, but I don't care to do that, especially on the longer (real) programs that I take apart.

All the disassemblers except MD86 generate the instruction **mov si,122h** at address 109 in place of the **mov si,offset months** instruction in the example source file. In fact, only MD86 seems to try to determine whether immediate values are offsets or numbers. Although Sourcer knows that the month-name table is referenced and includes a label for it, it does not use the label in the main program. Strange, no? Interestingly, both Dis•Doc and Snoop messed up the first part of the name-table area—and this is simple code.

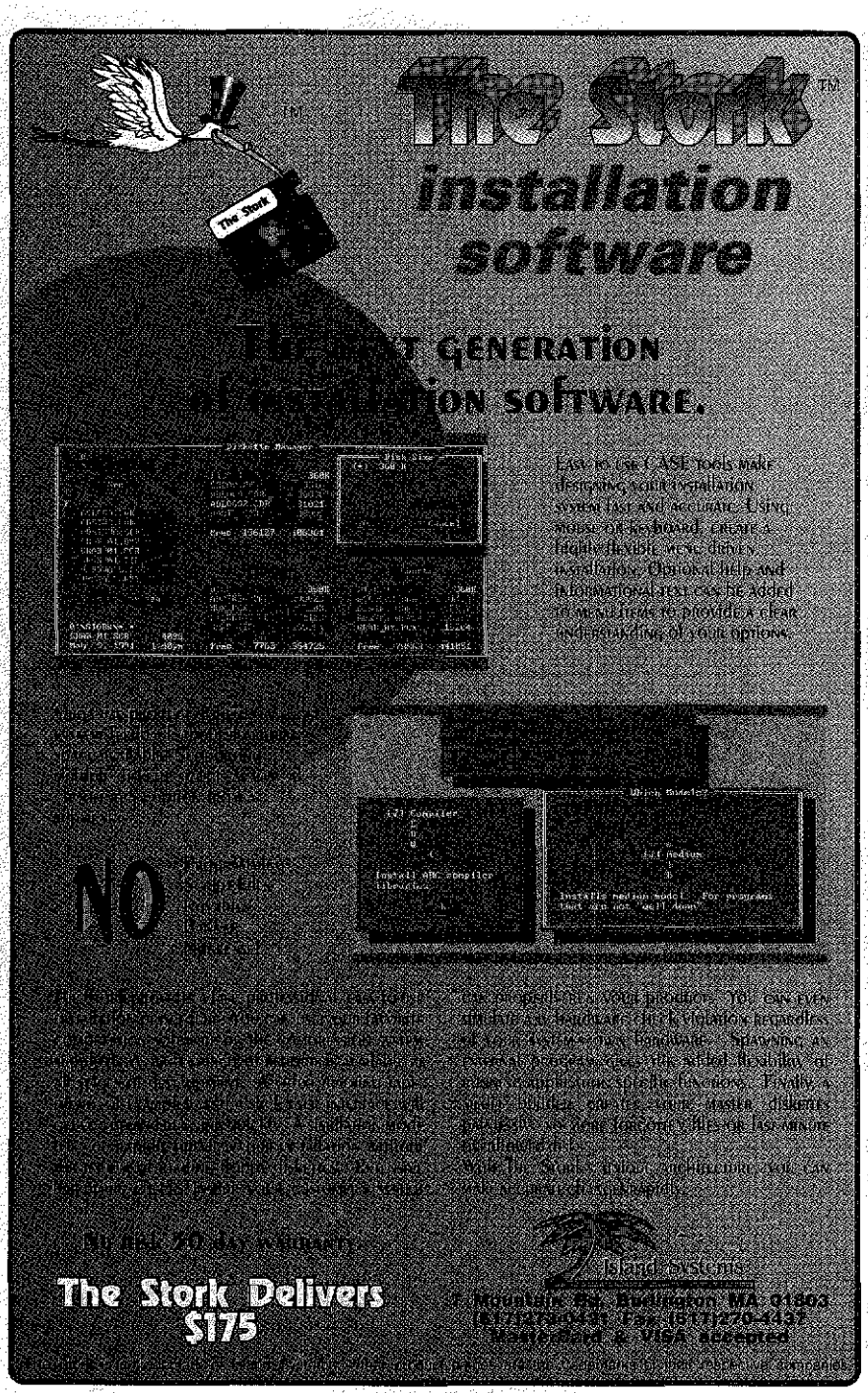
Each of these programs has good and bad points, and each user has pet peeves. My intent here is to point out that the review did not shed much light on these products that would be of help to a prospective purchaser. I hope that Brett's next review will delve more deeply into the products.

Joan Flugel
Sunol, CA

Thanks for Brett Glass's "Disassembler roundup" article. I do a lot of disassembly—some for the fun of it, and some to deal with undocumented code from defunct sources.

Glass is right that Sourcer is geologically slow; let it run overnight while you sleep. The huge listings it produces are nearly as incomprehensible as a raw hex dump; kilobytes of code become megabytes of listing.

I have had Sourcer for a couple of years, but I don't use it anymore. Instead, I use DEBUG, with redirection of input and output. Its simplicity is an advantage:



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John Sprung
Universal City, CA

GLASS'S MODEST PROPOSAL

I'm sorry that Mr. Janecki interpreted my remarks to mean that I dislike disassemblers. I do *like them—I'd just like to see them do their jobs better and faster.*

Two of the biggest stumbling blocks for any disassembler—including those I reviewed—are separating code from data and interpreting data structures. Most disassemblers are confused when the contents of a register vary on different passes through the same code, and even those that do register-level simulation often fail to predict the result of an address calculation. The four disassemblers I examined all had trouble determining whether a constant loaded into a register was an address, an offset from a base address, or a value whose function was strictly mathematical.

What is the best way to differentiate code from data? How can one know exactly how the parts of a program work when the code is actually running? I'd like to stick my neck out one more time on this issue and propose a new approach.

Intel's 80386 and 80486 microprocessors can run programs in the virtual 8086 mode, in which every instruction is subject to scrutiny by another program that monitors it and controls the machine. What if one were to construct a monitor program that snooped on an application as it was running—noting where the instructions were and what the registers contained at key points—and fed that information back to the disassembler? If the user exercised even 30% of the program during such a run, the hidden monitor could learn enough about the program to make the test easily decipherable.

Creating such a monitor/disassembler combination wouldn't be easy. Virtual 8086 mode is tricky and is not well documented. An inefficient monitor program could slow the application down intolerably, making it difficult to run test cases. And if the application used EMS, the monitor might have to emulate this function to exercise the expanded memory code. Still, the ability to decipher programs would be well worth the effort.

An ideal disassembler would be able to figure out everything about a program with little or no user input. Although none of the reviewed disassemblers has this capability, this proposal might help to make such products possible in the future.

Brett Glass
Palo Alto, CA

ERRATUM: A wrong telephone number for MetaWare Inc. appeared in "Impressions," *PJ* 9.3, p. 78. The correct number is (408) 429-6382.

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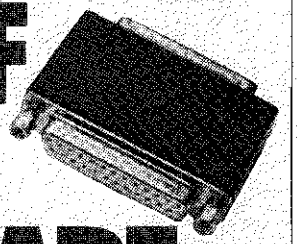

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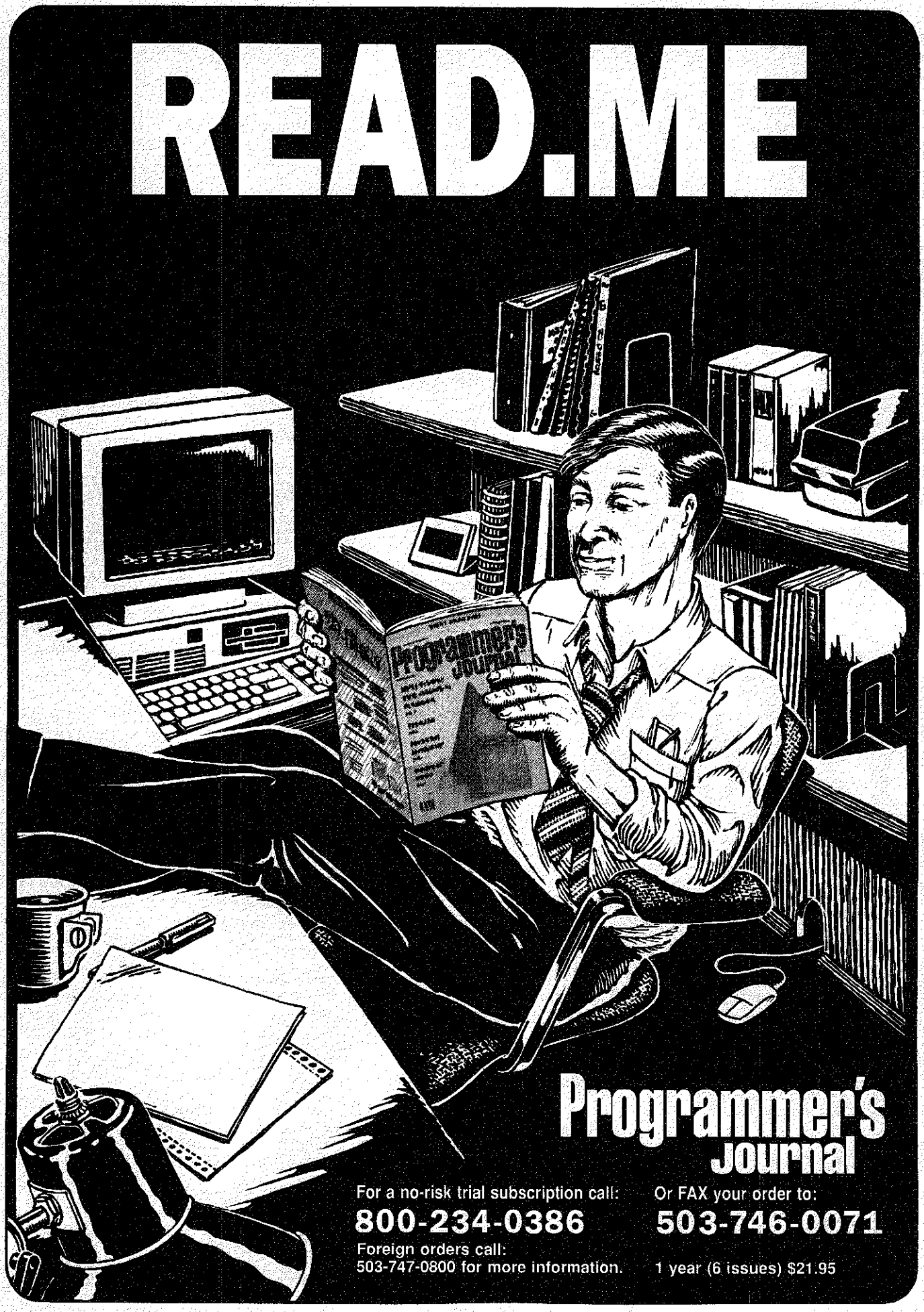

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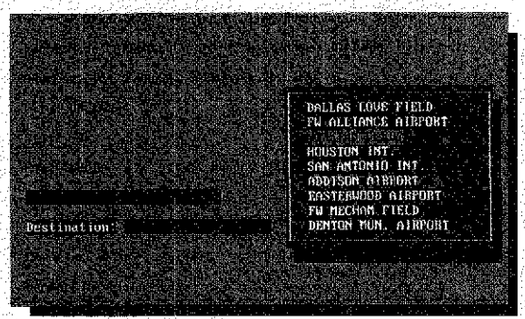

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Pink noise

By Frank D. Greco

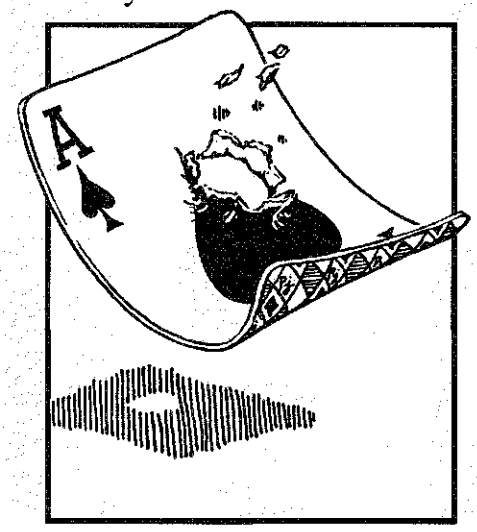

ILLUSTRATION BY JIM CARPENTER

The recently formed ACE (Advanced Computing Environment) group—which combines Compaq, Microsoft, Silicon Graphics, MIPS, DEC, and others—is a collaboration of companies that have not made it in the workstation field. Compaq wants to escape the Intel jail. Microsoft is still trying to force-feed us OS/2 (MS wants you to call it "NT" so you won't think it's the failed OS/2). Silicon Graphics wants desperately to be a big-time workstation vendor (and needs money to do so). MIPS is still pushing their chip as a standard (a standard that is controlled by the MIPS corporation—unlike SPARC, which is controlled by SPARC International, not Sun). And DEC is trying anything to buy time for their own proprietary chip, which won't be ready for another two years. (My DEC prognostication: "swing and a miss, strike three.")

I've never seen such a motley crew of workstation hopefuls. Within this aggregate are five camps of operating system standards (SVR4 Unix, Ultrix, OS/2, OSF/1, and DOS), two processor standards (Intel and MIPS), three standard bus architectures (DEC, VME, and EISA), three user interface standards (Windows, Motif, and Presentation Manager), two byte-ordering standards (big-endian Silicon Graphics style and little-endian PC style à la DEC and Microsoft) and two graphics standards (Silicon Graphics and PEX).

This is a standard environment? Who's kidding whom?

MIPS CHIP SLIP

What's the real reason behind Compaq's choosing the MIPS chip? Compaq CEO Rod Canion was quoted as saying that Compaq wanted a high-performance, multiple-source chip whose manufacturer does not build systems and compete with its customers, like Sun or Intel does. Somebody should tell Mr. Canion that MIPS has been selling a complete line of "Magnum" workstations and file servers based on the company's own chip. Do you think that MIPS will stop making their own workstations and higher-profit-margin servers because Compaq is one of their OEMs? Not likely.

To succeed in the high-performance workstation market, Compaq must start with a commodity chip like the SPARC. Having a small piece of a large SPARC market is much better than having a large piece of a nonexistent MIPS market (MIPS has posted two financially disappointing quarters in a row). And if they think that having Microsoft's OS/2 on their side is going to help them, Bill Gates is better at selling snake oil than is DEC's CEO, Ken Olsen.

The acquisition of 13% of Silicon Graphics will benefit Compaq's Intel-based PCs more than anything. An MS-DOS-based Compaq 486/586 box with sexy SGI graphics will make many a CAD/CAM user drool. (SGI has been trying to sell their PC graphics boards for a long time; they have virtually no distribution channel.) Unfortunately, IBM also owns a substantial chunk of SGI and uses some of this graphics technology in their RS/6000 workstation. IBM is also rumored to use SGI technology in their PS/2 machines. The IBM connection significantly offsets the competitive advantage of Compaq's minority SGI investment.

I think Compaq chose the MIPS chip because they wanted to be seen as a market leader. But now they've become part of an amorphous pseudo-standards-setting committee (along with such industry "stalwarts" as DEC, Unisys, Wang, and Control Data Corp.) that's agreeing to use OS/2 as part of a technology that won't be ready for at least two years (by which time Sun will have a huge lead).

Compaq's expertise in packaging systems and their tremendous advantage with the VAR channels would have given Sun a run for their money; it seems logical for Compaq to have chosen SPARC. Did Microsoft swing the Compaq cloners away from the SPARC camp? Mean Green knows that controlling the operating system and user interface is a tremendous strategic advantage. If the world went SPARC and Unix, Gates's group would lose its edge.

X-RATED WINDOWS

First the *Wall Street Journal* reported that Microsoft had abandoned OS/2 development and even quoted some Microsoft executives as saying that MS would be concentrating on Windows for future products.

The next day, presumably after someone at IBM read the paper, Microsoft issued a statement that identified IBM as doing the near-term OS/2 and Microsoft as doing the far-term OS/2 (aka NT). I guess MS forgot that IBM is still a very large customer of theirs. Despite the correction, the truth is out: Mean Green will concentrate on an architecture-independent Windows, not on OS/2.

Microsoft knows that Windows represents large licensing profits and a huge business advantage for their applications division. Windows over a RISC platform would even give them a foot (or at least a toe) in the workstation door. It seems that the PM/X (Presentation Manager

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over X Windows) project within Microsoft is still alive, but with Presentation Manager DOA, it's now MS Windows over X.

THE S-BUS STOPS HERE

If you want to run high-performance PC programs on your SPARCstation, you can get 80386 and 80486 S-Bus boards from a variety of vendors. As rumored in *Digital News*, Sun will shortly announce a 486 to hang off the SPARCstation's S-Bus, so you can run your favorite MS-DOS programs in an OpenWindows window.

POINTER POINTERS

Proxima Corporation has some high-quality LCD projection systems for PCs and Macintoshes. They recently announced a wireless pointing device that can be used on a projected image. A camera mounted on the projection panel actually reads the pointer's light off the projected image. With this device, you no longer need another person operating the computer while you speak, making it the perfect choice for one-person presentations.

DRIVING MISS DAISY

Toshiba, Prairietek, and Areal Technology have shown single-platter, 2.5-inch disk drives that are 0.75 inches tall and weigh 6 ounces. They range in capacity from 20 to 150 MB. These drives are perfect for notebook computers. It's only a matter of time before multiplatter versions with capacities of more than 300 MB appear.

Also expect to see 1-gigabyte, 3.5-inch drives at next year's Comdex.

LAPSE OF LUXURY

Toshiba is selling their SPARC laptop only in Japan because of an agreement with Sun. This agreement will run out in late 1991 or early 1992. According to Toshiba sales representatives, the company is scheduled to roll out a series of SPARC workstations and laptops for the American market.

SUNS AND SUDS

I almost fell out of my chair while watching ESPN in late April. After a report on the Foreman vs. Holyfield boxing match, some coverage of the Masters golf tournament, and a bit on overpaid baseball players, what should my wondering eyes behold but a commercial for Sun Microsystems. It's incongruous to see a Sun spot on the tube following a message from Miller Lite.

ECLIPSED BY SPARC

It looks as though Intergraph will eschew their proprietary Clipper RISC chip and use the SPARC in future workstations. Intergraph, which does a huge business with the government and large electronic design companies, struck a sizeable OEM deal with Sun. All of the company's software will be ported over to SPARC-based machines. Clipper-based

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Intergraph workstations hold 4% of the worldwide workstation market.

NICE THREADS

At a recent AT&T System V Release 4 conference at the Bell Laboratories in New Jersey, AT&T's technical rep stated that they were not putting lightweight processes (LWP) in SVR4. I was told that their implementation of **fork** (the Unix system call that creates a new process) is so efficient that SVR4 does not need LWPs.

AT&T doesn't realize that the biggest advantage of LWPs is that the processes (actually, multiple threads of a single process) share the same data space; heavyweight processes do not. You still need expensive Unix IPC to communicate among heavyweight processes, offsetting any performance increase from their faster forking.

With LWPs, if a thread needs some data from another thread, you just use it! Of course, if more than one thread needs a common data structure, you still have to coordinate access using some sort of monitor (semaphore) mechanism.

Despite its move toward SVR4, SunOS will also accommodate multithreading in their version of the OS. I imagine that, like Mach, multithreadedness will find its way into future versions of the Unix kernel.

THERE'S JOY IN MUDVILLE

A few years back, Sun head techno-nerd and industry personality Bill Joy said that Sun would go after the graphics market. The GX/GXP graphics co-processors and 30-MIP SPARCstation 2 workstations were initial steps toward replacing Silicon Graphics as the king of the graphics-workstation hill.

Now Sun has taken another large step toward graphics dominance by acquiring the technology, patents, and principals of Sutherland, Sproull, and Associates (SSA). This acquisition is significant: SSA has some very advanced graphics technology. They have built extremely realistic real-time flight simulators for the military. Back in the 1960s, Dr. Sutherland built the first computer program that could be called direct-manipulation (a MACpaint-type program).

Dr. Sutherland and Dr. Sproull—both former Xerox PARC members—will be joining Sun Laboratories, which concentrates on commercializing technology for future Sun projects.

FEATS OF CRAY

Cray is investigating a future supercomputer that can also run commodity software. They are evaluating whether to use SPARC or MIPS chips. Given the many Sun-to-Cray bridges out there in academia (such as Sun/Cray Hyperchannel connections, Sun graphical front-ends to Cray floating-point power, etc.), the smart money is on SPARC.

SURREAL SCREEN TEST

It looks as if the standard screen for portable computers will be small. The trend

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in notebook computing is for screens no larger than an 8½ by 11 piece of paper.

How about using virtual screens? Military jet pilots use this technology (called a "heads-up" display). A screen is displayed in virtual space in front of the pilot, who wears special goggles. A scaled-down version for PCs is available, but it's limited to two colors and CGA resolution. A heads-up display for portable workstations would come closer to the military version, wrapping a large virtual monitor around the user. The possibilities being offered by virtual reality proponents are even more hallucinogenic. My suggestion is tame by comparison.

IS A WARP DRIVE NEXT?

Intel appears to be working on a transputer-like processor called the iWARP chip. Rumor has it that Intel recently demonstrated a machine that contained 128 iWARP processors capable of supercomputer speed.

EYES ON TEXAS

Based on talks given recently by Sun executives Wayne Rosing and Andreas Bechtolsheim, I expect to see superscalar 60–100 MIPS SPARC workstations by the end of the year—with a generation jump (above 100 MFLOPS) in floating-point performance.

Judging from recent articles in technical journals, I expect that this upcoming machine will be all Texas-made, featuring the TI Viking SPARC chip and a gang of TI 390C602A floating-point chips.

SHOWING SOME GRAY

Look for Sun to move completely away from monochrome monitors and to switch to minimally 8-bit gray-scale monitors.

Also, expect them to use anti-aliasing for font rendering—the GX graphics accelerator, which is now standard on all SPARCstations, is capable of performing anti-aliasing in hardware. PD

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Don't be wrong about your rights

By William H. Roetzheim

At one point in my life I thought it would be fun to be a lawyer—or a fighter pilot or a computer programmer. I've had the opportunity to work as both a fighter pilot and a computer programmer, and I've outgrown my desire to be a lawyer. It seems that the most useful thing about lawyers is that they serve well as the brunt of lawyer jokes.

However, lawyers are definitely out there, and the long arm of the law is now invading the previously overlooked field of computer science. Taking some basic steps and thinking ahead can help you protect your rights from competitors and avoid possible lawsuits. As I said, I'm not a lawyer, and I'm not offering legal advice on matters such as filing for trademark protection, the specifics of which are covered in numerous books. Instead, I want to share some pointers on the types of things you should be aware of and might want to look into further.

ARE YOU TAKING NOTES?

You should be keeping an engineering notebook, where every idea you ever have gets written down, along with the date you have the idea. As you refine it (or add new facets), enter these modifications as well.

A notebook is a good idea even without lawyers—it allows you to keep track of ideas until you're able to pursue them. The law enters the picture under circumstances such as the following: suppose you develop a product based on an idea you had a long time ago, and someone claims that the product infringes on their patent. If you had the idea first, you have a valid argument against the attempt to enforce the patent.

Or perhaps you have a good idea that you begin to develop into a commercial

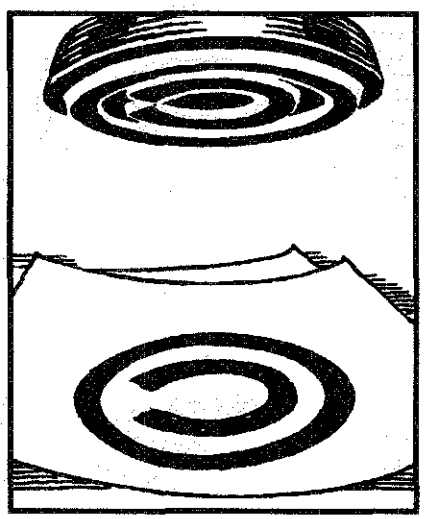

ILLUSTRATION BY JIM CARPENTER

success. Sometime later, a friend or co-worker tells you about their great new idea, which happens to be identical to yours. If the ex-friend or co-worker sues you for stealing, your engineering notebook will offer evidence that you had the idea independently.

Because your engineering notebook (or idea book) might be used as legal evidence, its format should follow its function. It should be bound, and each page should be numbered so that a missing or added page would be obvious. Blank books like this are available at many office supply stores and college bookstores.

Each entry in the notebook should be dated. Fill each page completely or draw a line through the unused portion of a page and initial it. You can have multiple entries per page; each page needs to be filled completely to avoid any suspicion that you added or modified an entry at a later date.

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William H. Roetzheim is a senior associate with Booz, Allen & Hamilton, and a noted author and speaker on software engineering topics. Bill can be contacted at Booz, Allen & Hamilton, Inc., Suite 109, 4025 Hancock Street, San Diego, CA 92110; (619) 223-5681.

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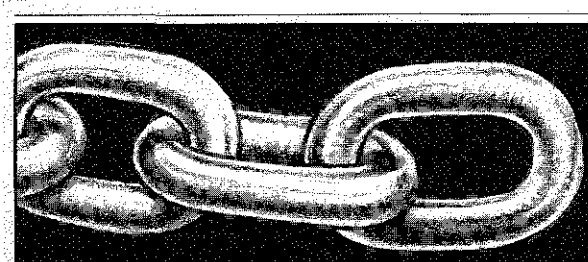
Take a few hours to begin implementing these ideas—then get back to your coding. The time you spend setting up procedures to protect yourself in the event of legal problems may very well save you thousands of dollars if push ever comes to shove.



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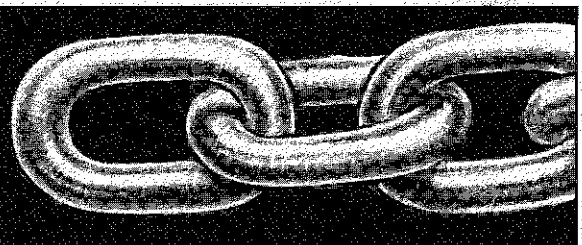

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A coat of many colors

Create striking results with animation for the Edsun CEG/DAC

By Michael Abrash

In the beginning, there was CGA. Then there was EGA, then VGA, and finally SuperVGA. Today, a number of innovative enhancements to SuperVGA (SuperDuperVGA?) are reaching the market. It's too early to tell which, if any, of these technologies will become widely used, but one strong contender is Edsun's Continuous Edge Graphics Digital-to-Analog Converter (CEG/DAC).

The CEG/DAC is a plug-in replacement for any VGA's standard DAC (the part that converts pixel attributes from the VGA chip into the analog voltages representing colors that are sent to the monitor). Several manufacturers are currently shipping CEG/DAC-equipped boards; I expect to see the CEG/DAC widely used on SuperVGAs in the $200–$300 range, with resolutions up to 1,024 × 768 in 256 colors.

The CEG/DAC is purely a color enhancer; it does nothing to increase screen resolution. However, by making more colors available and thereby making it possible to anti-alias and smooth images, the CEG/DAC can increase the screen's *perceived* resolution. This is not automatic—the programmer must take advantage of CEG/DAC's expanded color set—but it is possible.

How many colors does the CEG/DAC make available? Theoretically, it is possible to get more than 100,000 colors onto a single 1,024 × 768, 256-color screen, but because the CEG/DAC expands the color set via commands embedded in the bitmap, the number of colors available in a single frame depends greatly on the nature of the displayed image. This will become clearer when we discuss pixel weighting and dynamic palette loading, the two mechanisms by which the CEG/DAC expands the color set. For now, the key point is that the CEG/DAC's expanded color set means that selecting the color of a pixel is no longer as simple as putting a single value in display memory (0 for black, 1 for blue, 2 for green, and so on). With the CEG/DAC, color selection becomes a sequence over time, and the color of a given pixel can depend on values stored earlier in the bitmap. This, alas, leads to complexity.

I think highly of the potential of the CEG/DAC, but I have worried that it will be particularly difficult to use for animation and other real-time applications. Having previously expressed those concerns in print, I thought it only fair that I actually write a CEG/DAC animation application.

My application uses all the major features of the CEG/DAC in the course of color-animating a shifting background and animating four bouncing balls. Each ball is a different color, and each has a specular highlight. More than 200 colors are left free for other purposes. As you will see, the CEG/DAC requires complex programming and has its limitations. The results, however, can be striking—and, in the final tally, results are what really matter.

Michael Abrash works for Metagraphics, of Scotts Valley, California. He is the author of Power Graphics Programming *and* Zen of Assembly Language. *Contact Michael at 7 Adirondack Street, South Burlington, VT 05403 or via MCI Mail, user name MABRASH.*

A QUICK PRIMER

The CEG/DAC has three modes of operation. Advanced-4, used in 16-color modes, makes available eight primary colors and eight weightings. Advanced-4 is your only choice in 16-color modes, but it is especially difficult to program. Basic-8, used in 256-color modes, makes available sixteen primary colors and eight weightings between pairs of colors. The simplest CEG/DAC mode, Basic-8 is good for line-oriented drawing.

Advanced-8, also used in 256-color modes, is CEG/DAC's most powerful mode. In this mode, 223 independently selectable colors are available at any one time. In addition, 32 weightings of color pairs are available, in steps of 1/31, from all one color to all the second color. Finally, any one DAC palette register can be reprogrammed on the fly wherever six pixels in a row of the same color occur in the bitmap. (For details on all three CEG/DAC modes, along with a broader overview, see the "Graphics Programming" column in the April and May 1991

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issues of *Dr. Dobb's Journal*. Documentation and code for the CEG/DAC are available from Edsun in the *Edsun Continuous Edge Graphics Software Development Kit*. For now, these sources are your best bets for information; one can only hope that a book on programming the CEG/DAC appears soon.)

PALETTE LOADING

The special features of the Edsun chip operate by interpreting certain values in the pixel stream as opcodes rather than as color attributes. Information embedded in the bitmap can instruct the CEG/DAC to load any DAC register (palette entry) with a new color, thereby changing the color displayed by the corresponding pixel value. The sequence is shown in Figure 1. The first byte is the Edsun Dynamic Palette (EDP) opcode, which tells the CEG/DAC to interpret the next four pixels as RGB color components. This is followed by the number of the DAC register in which to store that color.

To have any effect, an EDP sequence must be scanned out as pixel information and sent to the CEG/DAC. An EDP sequence stored in off-screen memory would have no effect, because its bytes would never be sent to the CEG/DAC as pixels. Because EDP sequences are stored in the visible area of the bitmap, they are sent to the CEG/DAC *every frame*, so each EDP sequence loads a DAC register 60 or 70 times a second.

The instant the pixel containing the last byte of the EDP sequence arrives at the DAC, an EDP sequence changes the DAC register; thus, a register can be changed many times in a frame. For example, one EDP sequence can set DAC register 1 to green on scan line 0, and another can set DAC register 1 to blue on scan line 100; as a result, pixels with value 1 are green in the top half of the screen and blue in the bottom half. This procedure can increase the total color set available over an entire frame, as shown in Listings 1 and 2. (The number of colors simultaneously available is not increased, but clever allocation of objects and colors on the screen can work around this.)

What is on the screen while an EDP sequence is telling the CEG/DAC to load a DAC register? Whatever color happens to have been displayed for the pixel immediately preceding the EDP opcode. This means that EDP sequences can be placed in the bitmap only where there happen to be at least six pixels in a row of the same color, as is the case with the solid frame around the screen in Listing 1. Alternatively, EDP sequences could be stored in background areas of solid black or within solid areas of moving objects, or a black margin at each edge could be dedicated to EDP use, shrinking the usable screen area but increasing color selection.

I like EDP; it's my favorite feature of the CEG/DAC. EDP makes it possible to perform complex color animation (creating apparent motion by changing the colors displayed for a given pixel color) and, with proper planning, expands the number of independent colors available in the course of each frame. Both aspects of EDP are at work in Listing 1.

Note that the RGB values loaded by EDP are 8-bit values. In CEG mode, the CEG/DAC supports full 8-bit DAC registers, compared with the 6-bit DAC registers of a standard VGA. CEG mode can be enabled without enabling EDP. However, enabling EDP costs only one pixel value (191, the EDP opcode), and it's usually worth the loss of one of 224 simultaneous colors to be able to change DAC registers on the fly.

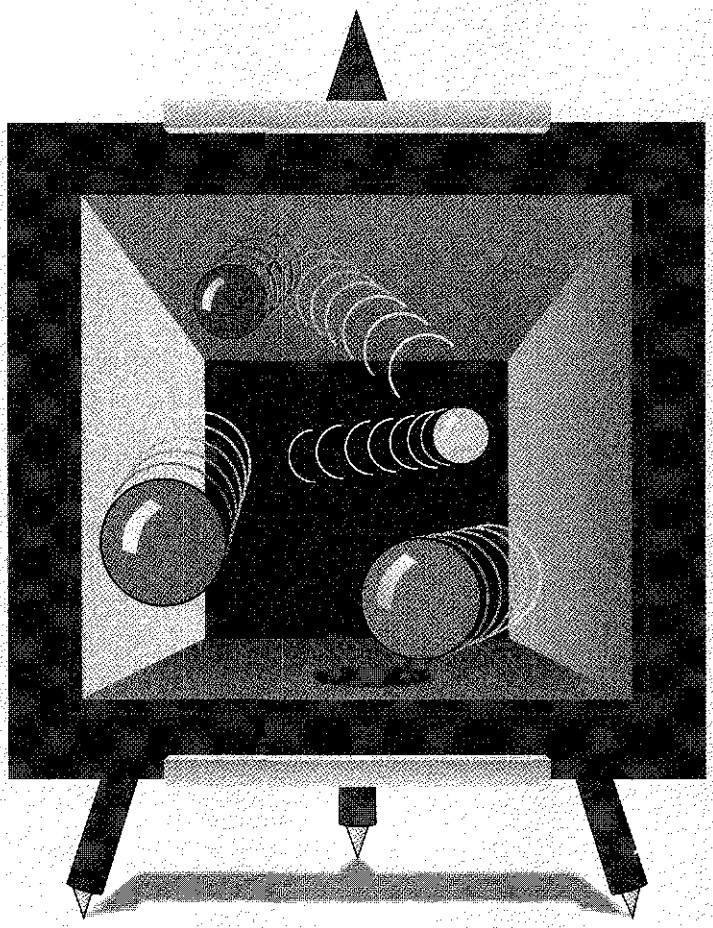

ILLUSTRATION BY ROB SCHUSTER

PIXEL WEIGHTING

Pixel weighting is the other primary feature of the CEG/DAC. A pixel weighting opcode specifies that a pixel's color is a weighted mix of the colors of two earlier pixels (see Figure 2). Table 1 shows the available mixes and shows that pixel weighting and EDP interpret 33 pixel values as opcodes rather than colors. This leaves 223 "normal" (non-EDP and non-pixel-weighted) colors available.

The CEG/DAC has a complex set of rules for interpreting various mixes of pixel colors and pixel weighting opcodes. The complications arise from Edsun's desire to be able to smooth narrow lines, which can cause considerable trouble when larger objects are pixel-weighted. For our purposes, we'll always start a pixel-weighting sequence with at least two pixels in a row of one color; this becomes the background color, color B. Then we'll have a single pixel of another color—the foreground color, color A; however, according to Edsun's rules, this pixel is still displayed in color B (don't ask why, that's just how it works). Following this will be at least two pixel-weighting opcodes. Therefore, at least three pixels are displayed in color B, followed by a minimum of two pixels displayed in mixes of colors A and B.

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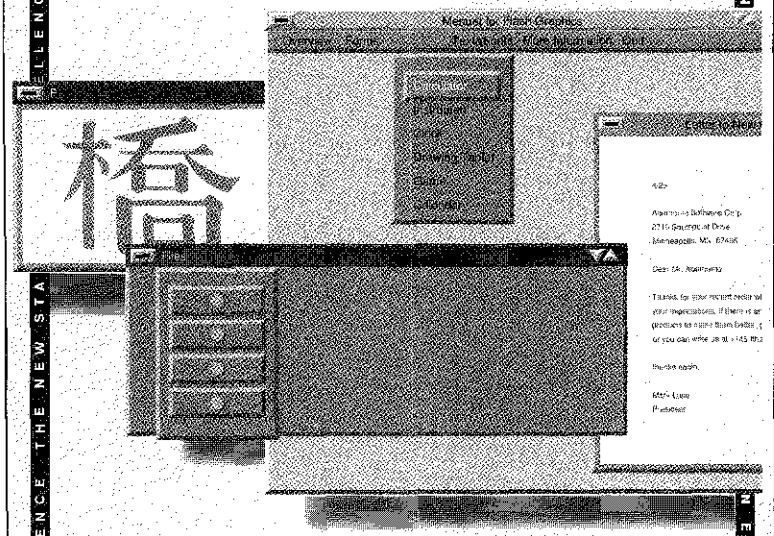

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LISTING 1

```
/* Performs 256-color animation on the Edsun DAC, taking advantage of
   both pixel weighting (selecting pixel colors as weighted averages
   of the colors of nearby pixels) and EDP (the ability to embed
   information in the bitmap that reprograms the DAC's palette during
   the course of each frame). Requires a VGA equipped with an Edsun
   CEG/DAC. All C code compiled with Borland C++ 2.0, operating in C
   mode, and using the small model */

#include <conio.h>
#include <dos.h>
#include <stdio.h>
#include <math.h>

#define PI  3.141592
#define ADVANCED_8_EDP  15 /* CEG/DAC mode # for Advanced-8 mode with
                              EDP enabled */
#define FRAME_WIDTH 10     /* width of frame around bouncing area */
/* Bounds within which balls bounce */
#define TOP_EDGE  FRAME_WIDTH
#define BOTTOM_EDGE (200-FRAME_WIDTH-1)
#define LEFT_EDGE FRAME_WIDTH
#define RIGHT_EDGE (320-FRAME_WIDTH-1)

typedef struct _RGB {   /* defines RGB triplet for a color */
   unsigned char Red;
   unsigned char Green;
   unsigned char Blue;
} RGB;

typedef struct _Image {     /* defines a drawable image */
   int Width, Height;       /* dimensions */
   unsigned char *PixMap;   /* image bytes */
} Image;

typedef struct _Ball {      /* defines a bouncing ball */
   int X, Y;                /* location */
   int XDir, YDir;          /* direction of movement */
   Image *BallImage;        /* image to draw for ball */
} Ball;

int main(void);
int EnableCEGMode(int);
void DrawFrame(int,int);
void SetEDPAtRight(int,RGB*,int,int);
void FillRect(int,int,int,int,int);
void DisableCEGMode(void);
void WaitVerticalSync(void);
void DrawImage(int,int,Image *);
void SetEDPAtLeft(int,int,int,int,int);
void AdvanceAndDrawBalls(Ball**,int);
void Delay(void);
void SetCyclingAttributes(RGB*);
void InitializePalette(void);

/* Byte pattern for balls that bounce horizontally */
unsigned char HBallPixMap[] = {
     1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
     1,  1,  1,  1,  1,  2,  2,  2,  2,  1,  1,  1,  1,  1,
     1,  1,  1,  2,  2,  3,212,208,204,200,218,  1,  1,  1,
     1,  1,  2,  2,  3,214,210,205,200,198,200,220,  1,  1,
     1,  1,  2,  2,  3,216,212,207,202,200,204,218,  1,  1,
     1,  2,  2,  2,  3,218,214,208,206,205,210,216,  2,  1,
     1,  2,  2,  2,  3,220,216,214,212,210,216,220,  2,  1,
     1,  2,  2,  2,  3,222,220,218,216,216,218,222,  2,  1,
     1,  2,  2,  2,  2,  2,  3,221,220,221,  2,  2,  2,  1,
     1,  1,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  1,  1,
     1,  1,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  1,  1,
     1,  1,  1,  2,  2,  2,  2,  2,  2,  2,  2,  1,  1,  1,
     1,  1,  1,  1,  1,  2,  2,  2,  2,  1,  1,  1,  1,  1,
     1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
};
/* Byte pattern for ball that bounces diagonally */
unsigned char DBallPixMap[] = {
     1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
     1,  1,  1,  1,  1,  4,  4,  4,  4,  1,  1,  1,  1,  1,
     1,  1,  1,  4,  4,  5,212,208,204,200,218,  1,  1,  1,
     1,  1,  4,  4,  5,214,210,205,200,198,200,220,  1,  1,
     1,  1,  4,  4,  5,216,212,207,202,200,204,218,  1,  1,
     1,  4,  4,  4,  5,218,214,208,206,205,210,216,  4,  1,
     1,  4,  4,  4,  5,220,216,214,212,210,216,220,  4,  1,
     1,  4,  4,  4,  5,222,220,218,216,216,218,222,  4,  1,
     1,  4,  4,  4,  4,  4,  5,221,220,221,  4,  4,  4,  1,
     1,  1,  4,  4,  4,  4,  4,  4,  4,  4,  4,  4,  1,  1,
     1,  1,  4,  4,  4,  4,  4,  4,  4,  4,  4,  4,  1,  1,
     1,  1,  1,  4,  4,  4,  4,  4,  4,  4,  4,  1,  1,  1,
     1,  1,  1,  1,  1,  4,  4,  4,  4,  1,  1,  1,  1,  1,
```

continued

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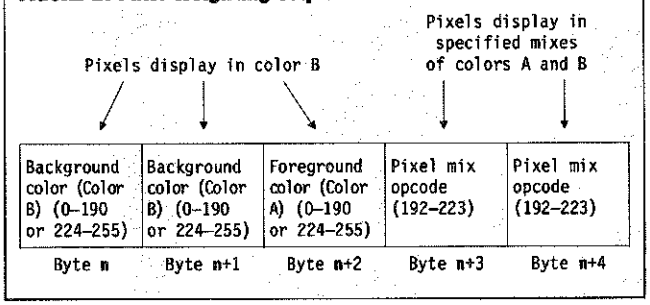
TABLE 1: Pixel values in Advanced-8 CEG mode 15

Pixel Value	Description
0	Attribute 0 (standard VGA; display the value in palette location 0)
1	Attribute 1 (standard VGA)
2	Attribute 2 (standard VGA)
.	
189	Attribute 189 (standard VGA)
190	Attribute 190 (standard VGA)
191	EDP (dynamic palette load) opcode
Pixel Weighting Opcodes	
192	100% (31/31) color A, 0% (0/31) color B
193	97% (30/31) color A, 3% (1/31) color B
194	94% (29/31) color A, 6% (2/31) color B
.	
222	3% (1/31) color A, 97% (30/31) color B
223	0% (0/31) color A, 100% (31/31) color B
224	Attribute 224 (standard VGA)
225	Attribute 225 (standard VGA)
.	
254	Attribute 254 (standard VGA)
255	Attribute 255 (standard VGA)

FIGURE 1: EDP sequence

191 (EDP opcode)	New red color component (0–255)	New green color component (0–255)	New blue color component (0–255)	Number of DAC register to load (0–190 or 224–255)
Byte n	Byte n+1	Byte n+2	Byte n+3	Byte n+4

FIGURE 2: Pixel-weighting sequence


Pixels display in color B
Pixels display in specified mixes of colors A and B
Background color (Color B) (0–190 or 224–255)
Background color (Color B) (0–190 or 224–255)
Foreground color (Color A) (0–190 or 224–255)
Pixel mix opcode (192–223)
Pixel mix opcode (192–223)
Byte n
Byte n+1
Byte n+2
Byte n+3
Byte n+4

If these conditions are observed (as in Listing 1), objects will draw predictably no matter what colors surround them, and the pixel-weighting opcodes will operate as specified in Table 1. If the conditions are *not* observed, surrounding colors may affect the object's appearance, or special line-drawing rules may come into play. If you don't want to observe the above limitations, refer to the CEG SDK documentation for more information.

I am not fond of pixel weighting—it's finicky and hard to program. It also creates serious problems when a pixel-weighted image is clipped or partially overwritten, because an interrupted pixel-weighting sequence often does not produce the same colors as the entire pixel-weighting sequence did. Nonetheless, pixel weighting does increase the available color set and can be useful for smoothing or for color gradients. Listing 1 illustrates the use of pixel weighting—and one of its drawbacks, as well.

FOLLOW THE BOUNCING BALLS

Listings 1 and 2 show a CEG/DAC animation application in which four balls of different colors, each smoothly highlighted, bounce around inside a multicolored frame against a background of smoothly scrolling colors. If you have access to a CEG/DAC, I suggest you run the application to give yourself a framework for the following discussion.

This example is not intended to be especially attractive, nor is it an ideal animation implementation. The balls are animated by building a blank fringe into each image so that when an image is moved, it overwrites completely and thereby erases itself at its last position. Overlapping images causes problems because the blank fringe is visible against the rearward image. Problems also can occur if an EDP sequence is scanned for video data while it's in the middle of being written to display memory (more about this later). For these and other reasons, it would be far better to perform page-flipped animation and to use a higher resolution than the 320 × 200 resolution of Listing 1. However, higher resolutions and page flipping would require more-complex code, and higher 256-color resolution would also require code that is specific to various VGA manufacturers. This article is bursting at the seams as it is, and the focus here is the CEG/DAC, so I've chosen to use the simplest 256-color mode and animation technique. Be aware, however, that techniques superior to those used in the sample program do exist.

That said, the sample application does illustrate a key tenet of CEG/DAC programming: tailor the application to the CEG/DAC's capabilities. Figure 3 (p. 35) shows how the sample application allocates the screen to take advantage of the CEG/DAC.

First, the 223 "normal" pixel attributes (which the DAC translates into colors) that are left when CEG mode is enabled are split up into several groups. Pixel attribute 0 is left as black; this is necessary to keep the overscan (screen border) area from becoming visible. Attribute 1 is the background color. Attributes 2 and 3 are used to draw the three horizontally bouncing balls, and 4 and 5 are used to draw the diagonally bouncing ball. Attributes 6–190 and 224–255 are set to a smoothly changing color sequence and then are used to draw a multicolored frame around the edge of the screen.

This frame is one way in which the application is tailored to the CEG/DAC; because it's more than five pixels wide and because the frame color doesn't change within a given scan line, you can store two EDP sequences on each scan line—one on each side of the frame—without altering the appearance of the frame. If the frame were 11 pixels wide, you could perform four EDP loads per scan line. By designing your applications to provide such areas of solid color, you can mask the loss of working screen space that EDP requires.

You could, of course, use attributes 6–190 and 224–255 for more than a mere frame. If a more sophisticated animation technique were used, you could use them to draw the background. You could also use them to draw non-CEG images or CEG images such as those drawn with attributes 2–5. Actually, you could accomplish

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```
    1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
};

Image HBall = {14,14,HBallPixMap};  /* image for horz bouncing balls */
Image DBall = {14,14,DBallPixMap};  /* image for diag bouncing ball */
Ball Ball1 = {60, 30, -1, 0, &HBall}; /* the four balls to bounce */
Ball Ball2 = {150, 90, 1, 0, &HBall};
Ball Ball3 = {220, 150, -1, 0, &HBall};
Ball Ball4 = {100, 120, -1, -1, &DBall};
Ball* BallArray[] = {&Ball1, &Ball2, &Ball3, &Ball4};
#define NUM_BALLS (sizeof(BallArray)/sizeof(Ball*))
int main() {
   int i, GreenTemp, BlueTemp, AttributeStart, FrameCount;
   int FrameDelay, Temp;
   union REGS regset;
   RGB Attribute1Settings[384];  /* used to store the EDP settings for
                                    attribute 1 */
   /* Set to the standard 256-color VGA mode, mode 0x13, 320x200 */
   regset.x.ax = 0x0013; int86(0x10, &regset, &regset);

   /* Now enable Advanced-8 CEG mode, so pixel value 191 becomes EDP
      opcode, and pixel values 192-223 become pixel weighting opcodes */
   if (!EnableCEGMode(ADVANCED_8_EDP)) {
      /* This isn't a CEG/DAC; back to text mode and we're done */
      regset.x.ax = 0x0003; int86(0x10, &regset, &regset);
      fprintf(stderr, "No CEG/DAC installed\n");
      return(1);
   }

   InitializePalette();    /* set up the palette */

   /* Draw a frame, using the colors 6-190 & 224-255 that we just set
      up to produce a smooth color gradient from top to bottom */
   DrawFrame(6,FRAME_WIDTH);

   /* Fill inside the frame with attribute 1, which we'll use EDP to
      change from line to line */
   FillRect(LEFT_EDGE, TOP_EDGE, RIGHT_EDGE+1, BOTTOM_EDGE+1, 1);

   /* Set the array of values for EDP loads of attribute 1 and put the
      EDP sequences for the first 200 of those colors at the right
      edge of display memory, in the frame */
   SetCyclingAttributes(Attribute1Settings);
   SetEDPAtRight(1, Attribute1Settings, AttributeStart = 0,
         sizeof(Attribute1Settings)/sizeof(RGB));

   /* Set the EDP sequences for the colors of the three horz balls */
   SetEDPAtLeft(2, 0, 0, 0x20, 29);  /* top ball is blue */
   SetEDPAtLeft(3, 0, 0, 0xAF, 30);  /* top ball highlight color */
   SetEDPAtLeft(2, 0, 0x20, 0, 89);  /* middle ball is green */
   SetEDPAtLeft(3, 0, 0x9F, 0, 90);  /* middle ball highlight color */
   SetEDPAtLeft(2, 0x20, 0, 0, 149); /* bottom ball is red */
   SetEDPAtLeft(3, 0xCF, 0, 0, 150); /* bottom ball highlight color */

   /* Now cycle through a frame at a time, moving the balls and
      advancing the EDP settings for the background (attribute 1) so
      the background appears to move. Stop when a key is pressed */
   for (FrameCount = FrameDelay = 1; ; ) {   /* draw on first frame */
      WaitVerticalSync();  /* wait until the end of current frame */
      if (--FrameCount == 0) {
         FrameCount = FrameDelay;
         AdvanceAndDrawBalls(BallArray, NUM_BALLS);

         /* Change the attribute 1 (background) EDP loads by one
            position in Attribute1Settings, wrapping from start back
            to end. This has the effect of shifting the EDP load of
            attribute 1 with any given color by one scan line, so the
            whole background appears to move one scan line */
         if (AttributeStart == 0)
            AttributeStart = sizeof(Attribute1Settings)/sizeof(RGB)-1;
         else
            AttributeStart--;
         SetEDPAtRight(1, Attribute1Settings, AttributeStart,
               sizeof(Attribute1Settings)/sizeof(RGB));
                        /* set the new attribute 1 EDP sequences */
      }
      if (kbhit()) {
         Temp = getch();
         if ((Temp == 'f') || (Temp == 'F')) {
            if ((FrameDelay -= 5) <= 0) FrameDelay = 1; /* faster */
         } else if ((Temp == 's') || (Temp == 'S')) {
            FrameDelay += 5;  /* slower */
         } else {
            break;   /* done */
         }
      }
   }

   DisableCEGMode();
   regset.x.ax = 0x0003; int86(0x10,&regset,&regset);  /* text mode */
return(0);
}

/* Enables the desired CEG/DAC mode. Returns 1 for success, 0 if no
   CEG/DAC is installed. */
int EnableCEGMode(int mode) {
   WaitVerticalSync();
   /* Write the CEG enable sequence, which is "CEGEDSUN" followed by
      the mode byte, to palette location 222 */
   outp(0x3C7,222); Delay(); outp(0x3C9,'C'); Delay();
   outp(0x3C9,'E'); Delay(); outp(0x3C9,'G'); Delay();
   outp(0x3C7,222); Delay(); outp(0x3C9,'E'); Delay();
   outp(0x3C9,'D'); Delay(); outp(0x3C9,'S'); Delay();
   outp(0x3C7, 222); Delay(); outp(0x3C9,'U'); Delay();
   outp(0x3C9,'N'); Delay();
   outp(0x3C9, mode); Delay();   /* write the CEG mode */

   /* At this point, CEG mode should be enabled. Make sure this really
      is a CEG/DAC */
   outp(0x3C6, 0xFF); Delay();   /* enable all DAC mask bits */
   if ((inp(0x3C6) & 0x70) == 0x70)
      return(0);  /* no version # bit is 0; this is not a CEG/DAC */
   else
      return(1);  /* this is a CEG/DAC, and CEG mode is now enabled */
}

/* Disable CEG mode by writing to palette location 223 */
void DisableCEGMode() {
   WaitVerticalSync();
   outp(0x3C8, 223); outp(0x3C9, 0); outp(0x3C9, 0); outp(0x3C9, 0);
}

/* Wait for the leading edge of vertical sync */
void WaitVerticalSync() {
   while (inp(0x3DA) & 0x08) ;      /* wait for not vertical sync */
   while (!(inp(0x3DA) & 0x08)) ;   /* wait for vertical sync */
}

/* Advance each ball and draw it (the blank fringe around each ball
   erases it at the old location) */
void AdvanceAndDrawBalls(Ball** BallPtrPtr, int NumBalls) {
   int i, Temp;
   Ball *BallPtr;

   for (i=0; i<NumBalls; i++) {
      BallPtr = *BallPtrPtr++;   /* point to current ball */
      /* Advance the X coordinate, bouncing if frame reached */
      Temp = BallPtr->X + BallPtr->XDir;
      if ((Temp < LEFT_EDGE) ||
            ((Temp + BallPtr->BallImage->Width) > RIGHT_EDGE)) {
         BallPtr->XDir = -BallPtr->XDir;  /* bounce in X dir */
         Temp += BallPtr->XDir;
      }
      BallPtr->X = Temp;
      /* Advance the Y coordinate, bouncing if frame reached */
      Temp = BallPtr->Y + BallPtr->YDir;
      if ((Temp < TOP_EDGE) ||
            ((Temp + BallPtr->BallImage->Height) > BOTTOM_EDGE)) {
         BallPtr->YDir = -BallPtr->YDir;  /* bounce in Y dir */
         Temp += BallPtr->YDir;
      }
      BallPtr->Y = Temp;
      /* Draw the ball at the new location */
      DrawImage(BallPtr->X, BallPtr->Y, BallPtr->BallImage);
   }
}

/* Used to provide a brief delay between OUTs */
void Delay() {
}

/* Set AttributeArray to contain a color sequence gradually
   cycling through each primary color */
void SetCyclingAttributes(RGB* AttributeArray) {
   int i;

   for (i=0; i<64; i++) {
      AttributeArray[i].Red = i;      /* ascending red */
      AttributeArray[i].Green = 0;
      AttributeArray[i].Blue = 0;
      AttributeArray[i+64].Red = 63-i; /* descending red */
      AttributeArray[i+64].Green = 0;
      AttributeArray[i+64].Blue = 0;
      AttributeArray[i+128].Red = 0;  /* ascending green */
      AttributeArray[i+128].Green = i;
      AttributeArray[i+128].Blue = 0;
      AttributeArray[i+192].Red = 0;  /* descending green */
      AttributeArray[i+192].Green = 63-i;
      AttributeArray[i+192].Blue = 0;
      AttributeArray[i+256].Red = 0;  /* ascending blue */
      AttributeArray[i+256].Green = 0;
      AttributeArray[i+256].Blue = i;
```

continued

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the multicolored effect of the frame equally well by drawing it in just one attribute and performing an EDP load on each line, as is done with attribute 1 (which we'll get to next). I've drawn the frame with hundreds of attributes to show that they are indeed available. When you watch the sample application in action, remember that only five palette entries are used to draw the entire background and the balls; the other 218 attributes, including all the colors in the frame, are available for any CEG-style use you desire.

COLOR ANIMATION WITH EDP

The sample application sets the background to a smooth color gradient by filling the interior of the frame with attribute 1, then storing in the right edge of the frame EDP sequences that change the setting of DAC register 1 at the end of each scan line. The colors of the background pixels are then made to move over time by shifting by one the scan line on which each EDP sequence resides; this changes the color interpretation of the background pixels' attribute of 1, although the values of the background pixels' bytes in display memory do not change. The net effect is one of a colored background moving past in a downward direction. This can be used to create the illusion that the foreground objects, along with the viewing window, are moving upward.

Again, the application is designed to allow EDP to perform color animation; a vertically striped background wouldn't work at all. EDP is also used to affect the colors of the pixel-weighted foreground objects, as described below.

PIXEL WEIGHTING IN ACTION

As described above, each ball that moves in the foreground is handled via the simple animation technique of building into the ball image a blank fringe that overwrites the image at its previous position. In keeping with the rules specified above for pixel-weighting sequences, each ball has at least two pixels of attribute 2 (the ball attribute) at the left edge of each scan line, followed by one pixel of attribute 3 (the highlight attribute), followed by at least two pixels of pixel-weighting mixes.

The initialization of **HBallPixMap** in Listing 1 contains

- the blank fringe (composed of attribute 1, the background color);
- the ball attributes (attribute 2, always at least two pixels wide at the left);
- the highlight attributes (attribute 3, always one pixel wide immediately to the right of attribute 2; this pixel actually displays on the screen as attribute 2); and
- the pixel-weighting opcodes, in the range 192–223, that draw the highlighted area.

Within the pixel-weighted area, lower values weight pixels more toward attribute 3, and hence make them more highlighted. Only two attributes are used to draw each ball, but more than a dozen colors are produced, thanks to pixel weighting.

There are four balls, drawn in four

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colors, but there are actually only two ball images, using a total of four attributes. EDP is used to change the colors associated with the attributes (2 and 3) of each of the three horizontally bouncing balls, so the same image can be used for each. Of course, this works only because the balls never share the same scan line. The diagonally bouncing ball, which does share scan lines with the horizontal balls, must use two different attributes; if it used the same attributes, it would change colors as it moved up and down the screen past the various EDP loads. Again, the application is designed so that a single ball image can be used to draw three different balls in three different colors.

THE DARK SIDE

I mentioned the potential problems that occur when a pixel-weighting sequence is interrupted. This phenomenon is present in the sample application when balls cross, but it isn't noticeable because the balls are small and moving fast and because relatively low-intensity colors are used. To see the problem more clearly, you can press the *S* key several times to slow the animation down when two balls are about to intersect. (Press *F* to speed things back up.) As the balls slowly cross, you'll see two things happen: bright sparkles sometimes appear in the ball to the left, and at least part of the highlighted area in the ball to the right sometimes changes colors. (You'll also see the blank fringe around one ball, but that's an artifact of the animation approach, not the CEG/DAC.)

The sparkles to the left happen when the pixel-weighting mix is truncated to only one pixel-weighting opcode; this causes the special narrow-line mode to kick in, often producing too-bright or incorrectly colored pixels. The color change in the highlighted area occurs when the pixels that set the foreground and background colors for a pixel-weighting sequence in one ball are overwritten by the other ball; the colors of the other ball then serve as the mix sources to the pixel-weighting sequence, and the mixed pixels change color. If the effects aren't evident, change the EDP sequences to make all the highlighted colors bright white; the color problems will then be evident, even in normal operation.

In this case, I intentionally designed the application around a weakness of the CEG/DAC instead of a strength, to make the problem obvious. You could choose to ignore the problem, but given that high image quality is the whole point of the CEG/DAC, that seems self-defeating, especially for larger or slower-moving images. You can work around the problem by keeping the balls from intersecting—by bouncing them off each other, designing their paths so that they never intersect, removing balls from the screen when struck, and the like.

None of these solutions is ideal, however, which is why I don't much care for pixel weighting in animation; it creates as many problems as it solves. My preferred solution is to use EDP for drawing the balls; there's plenty of space for additional EDP sequences in the frame area, and it gives you superior color control with no intersection problems. The flip side is that drawing the balls with EDP

```
        AttributeArray[i+320].Red = 0;  /* descending blue */
        AttributeArray[i+320].Green = 0;
        AttributeArray[i+320].Blue = 63-i;
    }
}

/* Set up the palette with the colors for the outer frame (colors 6
   through 190 and 224 through 255) cycling through combinations of
   the three primary colors as determined by out-of-phase sine waves.
   (There's nothing profound about these colors; it just makes an
   attractive, multicolored border.) Also set attributes 4 and 5 to
   the colors for the ball that bounces diagonally, and sets attrs
   0-3 to black (attributes 1-3 will be altered via EDP later) */
void InitializePalette() {
    int i, ColorEntry;
    RGB PaletteTemp[256];  /* used to pass palette settings to BIOS */
    union REGS regset;
    struct SREGS sregset;

    for (i=0; i<4; i++) {
        PaletteTemp[i].Red = 0;     /* black */
        PaletteTemp[i].Green = 0;
        PaletteTemp[i].Blue = 0;
    }
    PaletteTemp[4].Red = 0;     /* the diagonal ball is cyan */
    PaletteTemp[4].Green = 0x20;
    PaletteTemp[4].Blue = 0x20;
    PaletteTemp[5].Red = 0;     /* highlight color for diagonal ball */
    PaletteTemp[5].Green = 0xAF;
    PaletteTemp[5].Blue = 0xAF;
    ColorEntry = 0;
    for (i=6; i<=255; ColorEntry++, i = ((i==190) ? 224 : i+1)) {
                                        /* skip i from 190->224 */
        PaletteTemp[i].Red = abs((int)(255.0 *
            sin((double)(ColorEntry+67)/217.0*PI)));    /* Red */
        PaletteTemp[i].Green = abs((int)(255.0 *
            sin((double)ColorEntry/217.0*PI)));         /* Green */
        PaletteTemp[i].Blue = abs((int)(255.0 *
            sin((double)(ColorEntry+133)/217.0*PI)));   /* Blue */
    }
    regset.x.ax = 0x1012;   /* set block of DAC registers function */
    regset.x.bx = 0;        /* set register 0 first */
    regset.x.cx = 190-0+1;  /* # of registers to set */
    regset.x.dx = (unsigned int)&PaletteTemp[0];
                            /* offset of array from which to set */
    sregset.es = _DS;       /* segment of array from which to set */
    int86x(0x10, &regset, &regset, &sregset); /* attributes 0->190 */
    regset.x.ax = 0x1012;       regset.x.bx = 224;
    regset.x.cx = 255-224+1;    sregset.es = _DS;
    regset.x.dx = (unsigned int)&PaletteTemp[224];
    int86x(0x10, &regset, &regset, &sregset); /* attributes 224->225 */
}
```

LISTING 2

```
; Assembly routines for Edsun CEG/DAC animation program.

SCREEN_SEGMENT  equ     0a000h
SCREEN_WIDTH    equ     320
SCREEN_HEIGHT   equ     200

; Draws a frame around the screen, drawing top scan line of the frame in
; color StartColor, the next in color StartColor+1, and so on up through
; color 190, then jumping to color 224 and continuing to color 255, and back
; around to color StartColor if the screen has that many scan lines.
;
; C near callable as: void DrawFrame(int StartColor, int FrameWidth);
;
; All assembly code tested with TASM 2.

parms   struc
        dw      2 dup (?)       ;pushed BP & return address
StartColor dw   ?               ;color of first scan line
FrameWidth dw   ?               ;width of frame
parms   ends

; Macro to advance to the next color, going from StartColor to 190,
; then to 224 up through 255, and then back to StartColor.
CYCLE_COLOR     macro
        local   NoTurnover,CycleColorDone

        inc     al              ;advance the color
        jnz     NoTurnover      ;didn't turn over from 255 to 0
        mov     al,byte ptr StartColor[bp] ;did turn over, force to
        jmp     CycleColorDone             ;  StartColor
NoTurnover:
        cmp     al,191          ;time to jump to second block?
        jnz     CycleColorDone  ;no, the color is fine as is
        mov     al,224          ;yes, jump to first color in 2nd block
CycleColorDone:
```

continued

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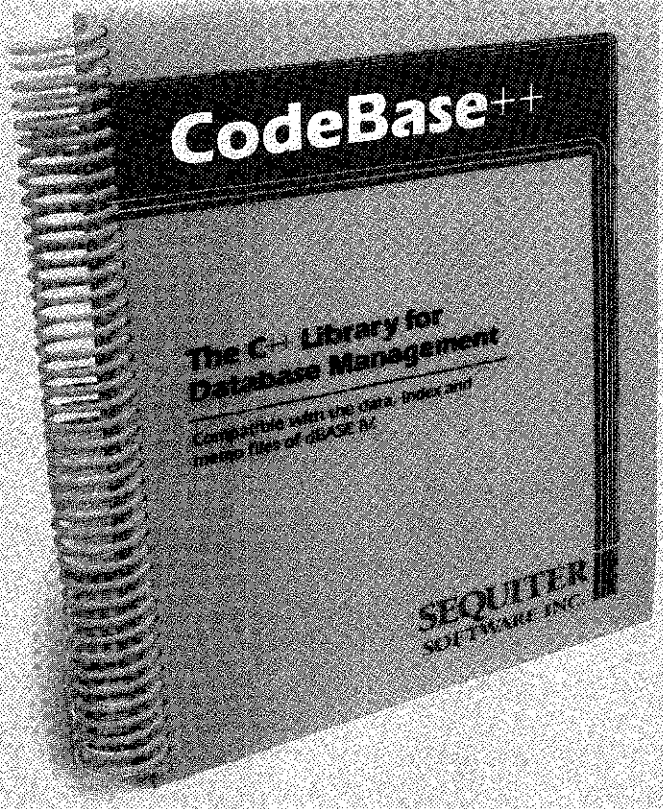

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requires the use of more palette entries than does pixel weighting.

IMPORTANT SAFETY TIP

As shown in Listing 2, EDP sequences are written to memory in a peculiar order: DAC register number first, then EDP opcode, and finally the RGB value to load. The reason for this is not obvious; to be honest, I discovered it only by chance.

Originally, I wrote EDP sequences to display memory in their natural order: EDP opcode first, then RGB value, and finally DAC register number, as shown in Figure 1. Usually, this worked fine. Occasionally, however, attribute 0 would change from black to dim red, and the overscan (border) region would become visible.

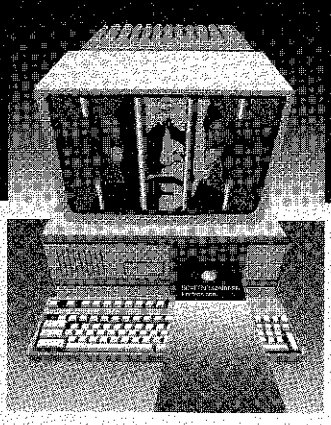
Here's what was happening. On occasion, I would write the EDP opcode and the RGB values to memory *just* before the VGA scanned those bytes of memory out and sent them to the DAC as pixel data. Therefore, the DAC would receive the EDP opcode and the RGB value intended for, say, DAC register 1. However, before the program got around to writing the value 1 (or whatever the intended DAC register was) at the end of the EDP sequence, the VGA would scan out that byte—which was still 0, because the number of the DAC register to load hadn't yet been written to it.

The CEG/DAC saw this sequence of pixels: EDP opcode, red value, green value, blue value, 0. The CEG/DAC dutifully did what that sequence specified, which was to load DAC register 0 (not 1) with the RGB value. By the next frame, of course, the EDP sequence was complete in memory, and the correct DAC register (register 1) was loaded. But by then the damage had been done; register 0, which I had not intended to modify, was changed.

The workaround (Listing 2) is to set the register number *first*, then the EDP opcode, and then the RGB values. That way, the EDP opcode can't help but be associated with the correct DAC register. The RGB values must be written after the EDP opcode, because if one of them is coincidentally the value 191 (the EDP opcode), and if the timing were exactly right, it could be incorrectly interpreted as the EDP opcode for a single frame. This sequence could cause an unintended DAC register to be loaded.

Another solution is to write EDP sequences only immediately following the vertical sync pulse, when no information is being sent to the DAC. However, it is hard to use this approach to write multiple EDP sequences reliably on computers of widely varying speeds. As is generally the case with the CEG/DAC, the best solution is to use page flipping, so intermediate bitmap states can't be misinterpreted. (Page flipping also avoids the possibility of partially written pixel-weighting sequences being sent to the CEG/DAC, which can result in one-frame "sparkles" as incorrect pixel values are generated.)

In sum, if there's any chance that the display memory to which you're writing



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```
        endm

        .model small
        .code
        public  _DrawFrame
_DrawFrame      proc    near
        push    bp              ;preserve caller's stack frame
        mov     bp,sp           ;point to local stack frame
        push    si              ;preserve caller's register variables
        push    di
        cld
        mov     ax,SCREEN_SEGMENT
        mov     es,ax
        sub     di,di           ;point to the first byte of the frame
        mov     al,byte ptr StartColor[bp] ;initial color
; First, draw the top of the frame.
        mov     dx,FrameWidth[bp] ;height of top part of frame
        mov     bx,SCREEN_WIDTH ;# of bytes per scan line
DrawTopLoop:
        mov     cx,bx
        rep     stosb           ;draw one scan line of the frame top
        CYCLE_COLOR             ;advance to the next color
        dec     dx              ;count down frame top scan lines
        jnz     DrawTopLoop
; Next, draw the sides of the frame.
        mov     cx,FrameWidth[bp]
        mov     si,cx           ;SI = FrameWidth for later
        add     cx,cx           ;FrameWidth * 2
        mov     dx,SCREEN_HEIGHT ;height of entire frame
        sub     dx,cx           ;height of sides =
                                ; SCREEN_HEIGHT - (FrameWidth * 2)
        sub     bx,cx           ;distance from one side to other =
                                ; SCREEN_WIDTH - (FrameWidth * 2)
DrawSidesLoop:
        mov     cx,si           ;width of each side = FrameWidth
        rep     stosb           ;draw one scan line of the left side
        add     di,bx           ;point to the start of the right side
        mov     cx,si           ;width of each side = FrameWidth
        rep     stosb           ;draw one scan line of the right side
        CYCLE_COLOR             ;advance to the next color
        dec     dx              ;count down frame top scan lines
        jnz     DrawSidesLoop
; Finally, draw the bottom of the frame.
        mov     bx,SCREEN_WIDTH ;# of bytes per scan line
DrawBottomLoop:
        mov     cx,bx
        rep     stosb           ;draw one scan line of frame bottom
        CYCLE_COLOR             ;advance to the next color
        dec     si              ;count down frame bottom scan lines
        jnz     DrawBottomLoop
        pop     di              ;restore caller's register variables
        pop     si
        pop     bp              ;restore caller's stack frame
        ret
_DrawFrame      endp

; Sets the 5 rightmost pixels on each scan line to perform an EDP load
; of the corresponding element from AttributeSettings to the DAC register
; specified by DACRegisterToLoad. (Every scan line reloads DACRegisterTo-
; Load.) Stores each EDP sequence in display memory in this order: DAC
; register #, the EDP opcode, and finally RGB color to load, in order to
; avoid accidentally loading the wrong DAC register if those bytes happen
; to be scanned just as the EDP sequence is half-written to memory.
;
; C near-callable as: SetEDPAtRight(int DACRegisterToLoad,
;       RGB* AttributeSettings, int FirstEntryToSet, int LastEntry);
SEARparms struc
        dw      2 dup (?)       ;pushed BP & return address
DACRegisterToLoad dw    ?       ;DAC register to perform EDP load to
AttributeSettings dw    ?       ;palette value table to load from
                                ; (array of RGB triplets)
FirstEntryToSet dw      ?       ;# of first entry in AttributeSettings
                                ; from which to load
LastEntry       dw      ?       ;# of last entry in AttributeSettings
SEARparms ends
        public _SetEDPAtRight
_SetEDPAtRight  proc    near
        push    bp              ;preserve caller's stack frame
        mov     bp,sp           ;point to local stack frame
        push    si              ;preserve caller's register variables
        push    di
        cld
        mov     ax,SCREEN_SEGMENT
        mov     es,ax
        mov     di,SCREEN_WIDTH-5 ;point to the first byte at which to
                                ; store EDP sequence on scan line 0
```

continued

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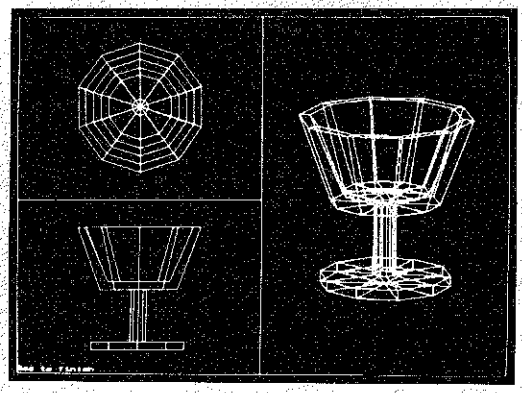

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```
        mov     si,FirstEntryToSet[bp]
        add     si,si           ;first entry index * 2
        add     si,FirstEntryToSet[bp] ;first entry index * 3
        mov     cx,AttributeSettings[bp]
        add     si,cx           ;point to first entry to load
        mov     bx,LastEntry[bp]
        add     bx,bx           ;last entry index * 2
        add     bx,LastEntry[bp] ;last entry index * 3
        add     bx,cx           ;point to byte after last entry to load
        mov     ah,byte ptr DACRegisterToLoad[bp] ;DAC reg to load
        mov     cx,SCREEN_HEIGHT ;put one EDP sequence on each line
SetEDPLoop:
        mov     es:[di+4],ah    ;set the # of the DAC register to load
        mov     al,191          ;EDP opcode
        stosb                   ;put EDP opcode in bitmap
        movsb                   ;copy over the RGB value to load with
        movsb                   ; this EDP opcode
        movsb
        add     di,SCREEN_WIDTH-4 ;point to the first byte of the EDP
                                ; sequence on the next scan line
        cmp     si,bx           ;have we wrapped off the end of the
                                ; attribute array?
        jb      EDPLoopBottom   ;no
        mov     si,AttributeSettings[bp] ;point to start of attr array
EDPLoopBottom:
        loop    SetEDPLoop
        pop     di              ;restore caller's register variable.
        pop     si
        pop     bp              ;restore caller's stack frame
        ret
_SetEDPAtRight  endp

; Fills rectangle from (StartX,StartY) to (EndX-1,EndY-1); row at EndY and
; column at EndX are not drawn. No clipping or error checking is performed.
;
; C near-callable as: FillRect(int StartX, int StartY, int EndX,
;       int EndY, int FillColor);

FRparms struc
        dw      2 dup (?)       ;pushed BP & return address
StartX  dw      ?               ;left edge of fill rect
StartY  dw      ?               ;top edge of fill rect
EndX    dw      ?               ;right edge of fill rect + 1
EndY    dw      ?               ;bottom edge of fill rect + 1
FillColor dw    ?               ;color with which to fill rect
FRparms ends

        public _FillRect
_FillRect       proc    near
        push    bp              ;preserve caller's stack frame
        mov     bp,sp           ;point to local stack frame
        push    si              ;preserve caller's register variables
        push    di
        cld
        mov     ax,SCREEN_SEGMENT
        mov     es,ax
        mov     bx,SCREEN_WIDTH
        mov     ax,StartY[bp]
        mov     si,EndY[bp]
        sub     si,ax           ;# of scan lines to fill.
        mul     bx              ;start of top scan line of rect
        mov     dx,EndX[bp]
        mov     di,StartX[bp]
        sub     dx,di           ;# of bytes across rect
        add     di,ax           ;ES:DI = upper left byte of rect
        sub     bx,dx           ;distance from end of one rect scan
                                ; line to start of next
        mov     al,byte ptr FillColor[bp] ;color with which to fill
FillLoop:
        mov     cx,dx           ;# of bytes across
        rep     stosb           ;fill one scan line
        add     di,bx           ;point to start of next line to fill
        dec     si              ;count off scan lines
        jnz     FillLoop
        pop     di              ;restore caller's register variables
        pop     si
        pop     bp              ;restore caller's stack frame
        ret
_FillRect       endp

; Copies the image pointed to by ImagePtr with the upper left corner
; at (StartX,StartY). No clipping or error checking is performed.
;
; C near-callable as: DrawImage(int StartX, int StartY, Image* ImagePtr);

DIparms struc
        dw      2 dup (?)       ;pushed BP & return address
DIStartX dw     ?               ;left edge of block destination
DIStartY dw     ?               ;top edge of block destination
ImagePtr dw     ?               ;pointer to Image struc to draw
DIparms ends

Image   struc
Width   dw      ?
Height  dw      ?
PixMap  dw      ?
Image   ends

        public _DrawImage
_DrawImage      proc    near
        push    bp              ;preserve caller's stack frame
        mov     bp,sp           ;point to local stack frame
        push    si              ;preserve caller's register variables
        push    di
        cld
        mov     ax,SCREEN_SEGMENT
        mov     es,ax
        mov     ax,SCREEN_WIDTH
        mul     DIStartY[bp]    ;start of top scan line of rect
        add     ax,DIStartX[bp]
        mov     di,ax           ;ES:DI = upper left byte of rect
        mov     si,ImagePtr[bp] ;point to Image struc to draw
        mov     dx,[si].Width   ;# of bytes across rect to draw
        mov     ax,[si].Height  ;# of scan lines to copy
        mov     si,[si].PixMap  ;image bytes to copy
        mov     bx,SCREEN_WIDTH
        sub     bx,dx           ;distance from end of one rect scan
                                ; line to start of next
CopyLoop:
        mov     cx,dx           ;# of bytes across
        rep     movsb           ;copy one scan line
        add     di,bx           ;point to next line to copy to
        dec     ax              ;count off scan lines
        jnz     CopyLoop
        pop     di              ;restore caller's register variables
        pop     si
        pop     bp              ;restore caller's stack frame
        ret
_DrawImage      endp

; Puts the EDP sequence that loads the specified RGB color into the
; specified DAC register (that is, palette location, changing the
; color of the corresponding attribute) in the second through sixth
; pixels of the specified scan lines. Like SetEDPAtRight, stores EDP
; sequences in DAC register #/EDP opcode/RGB order to avoid
; accidentally loading the wrong palette register by chance timing.
;
; C near-callable as: SetEDPAtLeft(int At  ibute, int Red, int Green,
;                                  int Blue, int ScanLine);

SEALparms struc
        dw      2 dup (?)       ;pushed BP & return address
Attribute dw    ?               ;DAC register to load (attribute for
                                ;  which to change color)
Red     dw      ?               ;red component to load
Green   dw      ?               ;green component to load
Blue    dw      ?               ;blue component to load
ScanLine dw     ?               ;scan line at start of which to put
SEALparms ends                  ;  EDP load

        public _SetEDPAtLeft
_SetEDPAtLeft proc      near
        push    bp              ;preserve caller's stack frame
        mov     bp,sp           ;point to local stack frame
        mov     ax,SCREEN_SEGMENT
        mov     es,ax
        mov     ax,SCREEN_WIDTH
        mul     ScanLine[bp]    ;start of scan line on which to load
        mov     bx,ax           ;ES:BX = start of scan line
        mov     al,byte ptr Attribute[bp]
        mov     es:[bx+5],al    ;DAC register to load
        mov     es:byte ptr [bx+1],191 ;EDP opcode
        mov     al,byte ptr Red[bp]
        mov     es:[bx+2],al    ;new red value
        mov     al,byte ptr Green[bp]
        mov     es:[bx+3],al    ;new green value
        mov     al,byte ptr Blue[bp]
        mov     es:[bx+4],al    ;new blue value
        pop     bp              ;restore caller's stack frame
        ret
_SetEDPAtLeft endp
        end
```


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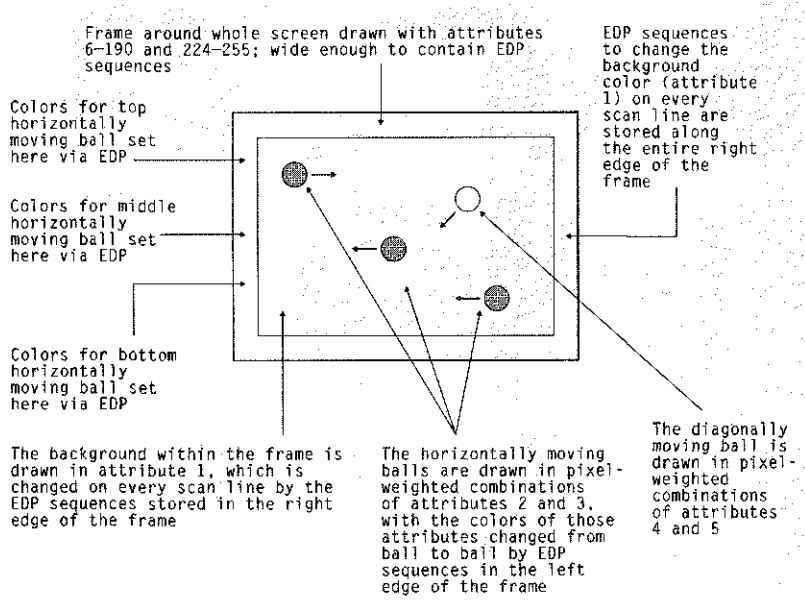
FIGURE 3: Screen layout in the sample application


Frame around whole screen drawn with attributes 6–190 and 224–255; wide enough to contain EDP sequences
EDP sequences to change the background color (attribute 1) on every scan line are stored along the entire right edge of the frame
Colors for top horizontally moving ball set here via EDP
Colors for middle horizontally moving ball set here via EDP
Colors for bottom horizontally moving ball set here via EDP
The background within the frame is drawn in attribute 1, which is changed on every scan line by the EDP sequences stored in the right edge of the frame
The horizontally moving balls are drawn in pixel-weighted combinations of attributes 2 and 3, with the colors of those attributes changed from ball to ball by EDP sequences in the left edge of the frame
The diagonally moving ball is drawn in pixel-weighted combinations of attributes 4 and 5

an EDP sequence could simultaneously be read to generate pixel data, you must ensure that the memory can never be in an intermediate state that could accidentally cause the wrong DAC register to be loaded. This one problem caused me much head scratching and gnashing of teeth, which I hope I've spared you.

ENABLING THE CEG/DAC

Enabling CEG mode is a simple matter of writing the characters "CEGEDSUN" to DAC register 222, followed by the number of the desired CEG/DAC mode. (See the CEG SDK documentation for a list of modes.) In CEG mode, bits 4–6 of the Mask register read back as the CEG/DAC version number, with at least one bit guaranteed to be 0. In non-CEG mode, or with a non-CEG DAC, bits 4–6 of the Mask register read back as the mask setting. Thus, CEG mode can be identified by enabling CEG mode as described above, then writing 0xFF to the DAC Mask register and immediately reading back the Mask register. If bits 4–6 are all 1-bits, it's not a CEG/DAC; otherwise, it is.

You will notice calls to **Delay** in **EnableCEGMode** in Listing 1. On my 8-MHz AT, **EnableCEGMode** would intermittently fail, even though a CEG/DAC was installed, until I put in delays between OUTs, perhaps because I have a prototype CEG/DAC. I recommend playing it safe and delaying between OUTs.

LOOKING BACK AND AHEAD

Was programming the CEG/DAC for animation as complex as I had feared? It *was* complex, but mostly because of learning to work with new technology, which is always a little mind-bending. In the end, the problems were solvable, and the results were definitely a cut above standard VGA.

In particular, EDP proved extremely valuable (once I had solved the problem of occasionally changing color 0 by chance timing). Pixel weighting has its uses but is frankly difficult to work with in an animation context; if I were doing this for a living, I'd focus on EDP. At any rate, I look forward to seeing the first commercial CEG/DAC-aware animation software, which should be like nothing else ever done on a $250 display adapter.

Less than 10 years ago, $250 wouldn't even buy a CGA! We've come a long way since then, and the adventure is just beginning. DJ

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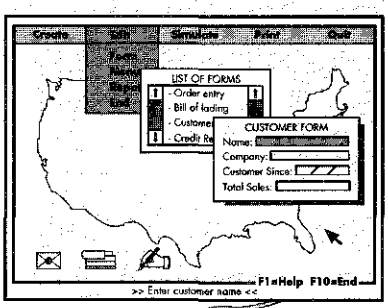

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Communicating over NetBIOS

Merge into the modem pool's fast lane with Turbo Pascal

By Brett Glass

The financial gurus all seem to be crying "recession," and many companies are taking belt-tightening measures. On the computer front, an area ripe for cost-cutting will be upgrades and peripherals—especially modems.

Installing a 2400-baud modem is more expensive than the $120 or so that the hardware costs. There's the matter of adding a phone line for it, which can get especially tricky on digital PBXes. Consider also the wiring costs, installation labor, and another $100 or so if you want a dedicated business phone line. The total expense clearly enters the realm of serious money.

That's why corporate computer users are probably going to see an increase in the number of modem pools. A modem pool is a group of modems—usually attached to a computer in a telephone closet—that can be shared by users on a LAN. Modem pools have their problems, but they also provide access for a fraction of the cost of a shiny new modem.

SLOW TURNAROUND

The main advantage of modem pools is their savings, and their biggest disadvantage is delays. IBM configured the original PC's BIOS to limit communications speeds to 9600 baud or less. At higher rates, there was a good chance that characters would be dropped. The reason for the limitation wasn't inefficiency in the BIOS code (which was very simple); rather, IBM was concerned that the processor might not have the "oomph" to field all of those characters at higher speeds.

Now consider the LAN situation. A LAN is much faster than a serial port, so raw throughput isn't a problem. Instead, the most serious problem is overhead: building, encoding, and sending the packets (even if they contain several serial characters) can involve many times the work of writing to a serial port. Thus, communications via a modem server still tend to suffer from disconcertingly long character turnaround times—a significant delay between the time you hit a key and the time it is echoed. But performance is usually fine for uploads and downloads as long as you use a "windowing" protocol (such as ZMODEM or CompuServe B+) to keep delayed acknowledgements from hurting your transfer rates.

LINKING ACROSS THE LAN

One of the knottiest problems that a LAN must handle is the interface between the communications software (say, CrossTalk, TAPCIS, or Procomm) and the remote modem. Had IBM designed its PC with more forethought, this wouldn't be a problem; there's a well-defined API that could hide the specifics of the hardware and make it easy to write a communications program. This is one area where the Macintosh and even Unix outperform the PC: the IBM PC BIOS provides a less-than-ideal interface. It insists on doing its own peculiar form of handshaking, which can disconnect or reset a modem. It refuses to transmit characters if the Carrier Detect line is off (making it necessary to dial a "smart" modem). Worst of all, it isn't interrupt-driven—it can drop characters even if the software polls it assiduously. For this reason, all quality communications software goes right to the hardware and takes over the UART chip.

This means that a LAN communications server needs help from the communications program, usually in one of two ways. First, the communications program can "force" itself to use the primitive BIOS services (provided through INT 14h), trusting the server to buffer characters so they don't get dropped. The advantage of this approach is simplicity: there are only four BIOS functions to know about (or six if you use the "enhanced" set provided by the PS/2 line), and they're all clearly documented in many reference books.

However, because the INT 14h functions weren't designed for modem pools,

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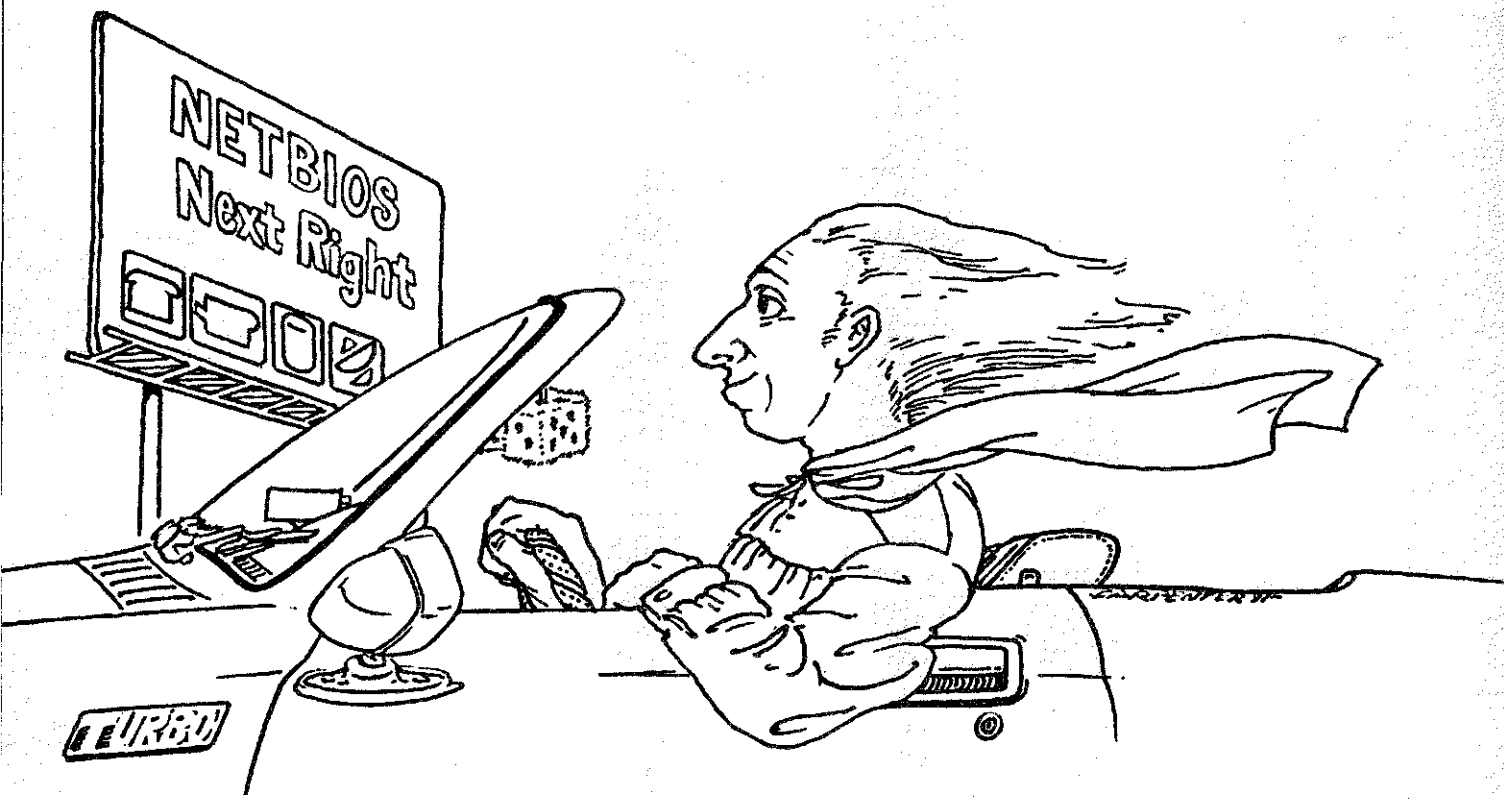

some desirable features aren't there. For instance, there's no provision to "open" and "close" a serial port; if users are to share the modems, some special mechanism must be devised to let them connect to and disconnect from a port. Nothing in the BIOS interface lets you specify which modem you want to use or find out which ones are available. Still, because the INT 14h interface is so well known, many LAN and communications software vendors support it. There's one other advantage: if you want to use your network communications server to capture output from an existing program that uses INT 14h, you can do so without changing anything. For instance, if you put a serial printer on your communications server, you can then print to it by using the DOS MODE command to redirect printer output.

The second approach is to use a different software interface to the modem server. There are two popular alternative interfaces: the NetWare Advanced Service Interface (NASI) was originally developed by Network Products Corporation for Novell; Network Products calls their version of the same API the Network Communications Services Interface (NCSI) (see Vendor Information, p. 42). NASI/NCSI use INT 6Bh, and the basic functions are mimicked by the Ungermann-Bass Network Interface (UBNI). The IBM Asynchronous Communication Services Interface (ACSI), which uses NetBIOS over Token Ring or the IBM PC Network, is most commonly used by corporations that have large investments in IBM networks and mainframes. Both interfaces have the functions that INT 14h lacks. However, literature on them is harder to track down, and they're not as widely supported. Some vendors have also added in their own advanced functions to INT 14h, but these functions aren't standardized.

SERVER PROTOTYPE

For the project described in this article, I wanted to prototype a communications server that would work with the widest possible variety of LANs and communications software. I therefore chose to implement the INT 14h interface (with the PS/2 extensions) and to use NetBIOS calls to interface to the LAN. NetBIOS has three key advantages over IPX and other proprietary protocols. First, every PC LAN uses or emulates it. Second, it's peer-to-peer (the communications server need not be a LAN server). Finally, it's available as a layer on top of TCP/IP, making it theoretically possible to have a modem server in another city across a nonproprietary WAN (imagine the phone bills you could save!).

I began by designing a test program, a simple terminal emulator that uses only INT 14h calls. This proved to be an excellent debugging tool. Because I had the source, I could run the emulator under Turbo Debugger and watch its every interaction with the communications server. I then started on the meat of the project: a small TSR to run in the client workstation, and a larger server program to provide the communications services.

NETBIOS OBJECTS

I built in NetBIOS support via an object-oriented NetBIOS unit that treats Network Control Blocks (NCBs) as objects. To access NetBIOS, you create NCBs, fill in the appropriate fields, and tell them what to do. The resulting code is easy to follow, especially if you're using "with" statements to shorten the names. The NetTools unit handles the most common network operations. Together, these two units do the bulk of the work for the client and the server. They are available (along with the test program) on this issue's code disk or on *PJ*'s BBSs (see p. 95).

Because a client will want to connect to the server for some period of time, I opted to use NetBIOS sessions—rather than datagrams—to establish the link. This approach has pros and cons: sessions make it easy to send and receive messages, but they can get cut off by adverse network conditions and require more code than datagrams. I chose to use sessions because they provide automatic confirmation of delivery; you don't have to worry about a message getting lost.

DIVISION OF LABOR

Another design consideration was how to split the work load between client and server. Because a workstation might put a

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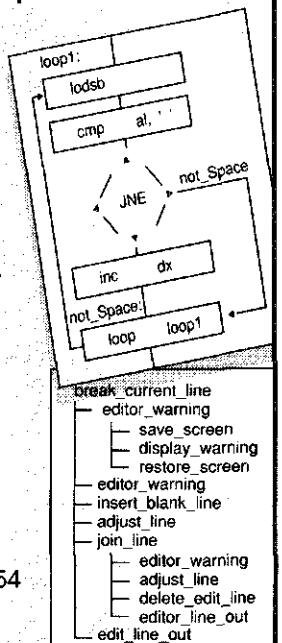

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LISTING 1

```
{
** Communications Client Version 1.0                    May 1, 1991 **
** Copyright 1987,1988,1991 by L. Brett Glass, Systems Consultant
}
program Client; {Client TSR}
uses NetBIOS,NetTools,DOS;

{$M 8192,0,0} {Use 8K of stack, no heap}
{$R-}
{$S-}
{$I-}       {Turn off space- and time-consuming options}
{$V-}

type
  PortNumType = 1..4;

type
  CommRegType = record
    case Boolean of
      TRUE: (dx,cx,bx,ax : Word);
      FALSE: (dl,dh,cl,ch,bl,bh,al,ah : Byte);
    end;
var
  myPermNodeName, remotePortName : NetName;
  biosPortNum : PortNumType;
  commSessionNum : Byte;
  oldInt14 : Pointer;
  clientSendBlock,clientRcvBlock : NCB;
  saveStackSeg : Word;
  saveStackPtr : Word;

const
  ERRORFLAG = $80; {Flag to indicate comm timeout or error}

procedure ValidateParms;
  var
    tempStr : String;
  begin
  if ParamCount <> 2 then
    begin
    Writeln('Usage: CLIENT <Network Name> <Port Number>');
    Writeln(' E.G.: CLIENT MyModem 2');
    Writeln('       Connects COM2: to a remote networked');
    Writeln('        communications port with the name MyModem');
    Halt
    end;
  tempStr := ParamStr(1);
  if (Length(tempStr) = 0) or (Length(tempStr) > 16) then
    begin
    Writeln('Error: Serial port/modem name must be 1 to 16 characters');
    Halt
    end;
  FillChar(remotePortName,SizeOf(remotePortName),' ');
  Move(tempStr[1],remotePortName[1],Length(tempStr));
  tempStr := ParamStr(2);
  if (Length(tempStr) <> 1) or (tempStr[1] < '1') or
    (tempStr[1] > '4') then
    begin
    Writeln('Error: Port number must be 1 through 4');
    Halt
    end;
  biosPortNum := Ord(tempStr[1])-Ord('1'); {BIOS uses 0=COM1, etc.}
  end; {ValidateParms}

procedure Connect;
  begin
  if not NetBIOSPresent then
    begin
    Writeln('Error: NetBIOS not available');
    Halt;
    end;
  if NetToolsGetMyName(myPermNodeName) <> GOOD_RTN then
    begin
    Writeln('Error: Unable to determine adapter status');
    Halt;
    end;
  {Do a call. Set up a session with five-second timeouts.}
  if NetToolsCall(myPermNodeName,remotePortName,10,10,commSessionNum) <>
GOOD_RTN then
    begin
    Writeln('Error: Unable to establish session with server');
    Halt;
    end;
```

continued

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premium on memory and would want the most compact client software possible, I made the client (Listing 1) very "dumb": it simply takes over INT 14h and watches for requests involving the remote serial port. When it finds such a request, it packs up the relevant registers and sends them to the server for processing. Were I converting this prototype into a commercial product, I'd also use other TSR space-saving techniques: I'd release my environment, put global data at the beginning, and leave initialization code at the end of the program so that it could be removed after it was used. However, this isn't possible with Turbo Pascal's memory model, so the prototype is larger than most commercial client programs.

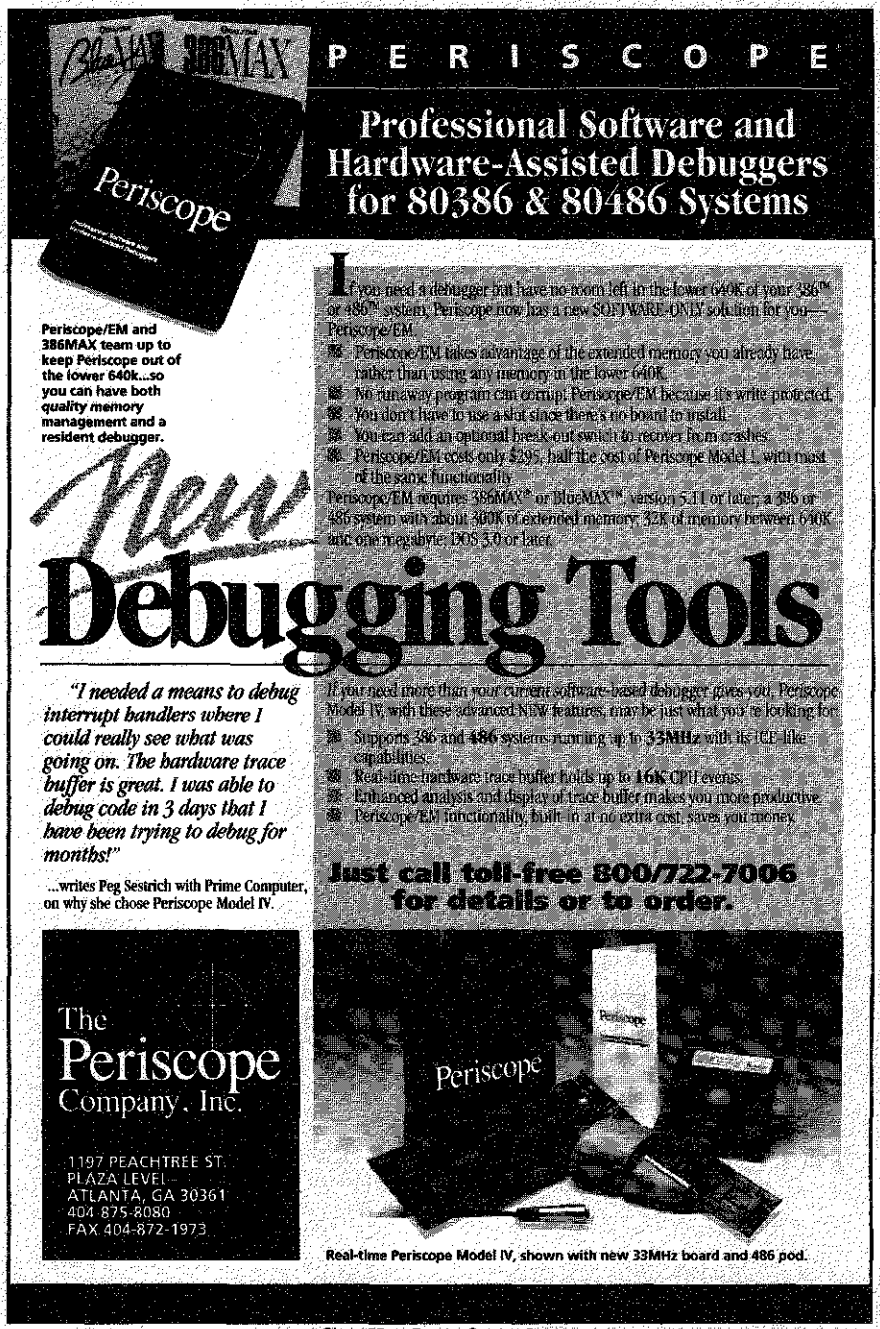
To invoke the client, type CLIENT <Network Name> <Port Number>. "Network Name" is the name of the server serial port, and "Port Number" is the port number it will have on the local machine (1 for COM1:, 2 for COM2:, etc.). This prototype client doesn't have an uninstall facility; it uses the specified port until the machine is rebooted or until the TSR is removed by a Mark/Release program.

The server (Listing 2) is more complex. It uses interrupts to handle incoming characters and maintains a circular buffer to prevent their getting lost. Note that the receive buffer is a "fall out" buffer—when it overflows, it loses the oldest character rather than the newest. If characters are received on a port that currently has no client, the next client that connects to the port can see the most recent input. This version of the server does not do interrupt-driven transmission, although it would be simple to add. Also, to keep it simple, this prototype server handles only one serial port. To add more, you would need to make arrays out of the global variables that hold information about each port.

This version of the server isn't a TSR. Although it's possible to make it one (and third-party software toolkits such as TesSeRact make it downright easy), my experience indicates that it may not be a good idea, especially if the server is handling even one high-speed modem. A server that functions as a TSR has to split its time with other programs on the machine, possibly delaying responses until NetBIOS is not busy (you can't send a reply from within a NetBIOS "post" routine) and a timer tick interrupt arrives to wake the server up. Even if you speed up the timer (it normally ticks only about 20 times a second) or use the real-time clock interrupt (which occurs about a thousand times a second), you may find that the server doesn't do a good job of keeping up.

LITTLE WHITE LIES

When I implemented the server, I found I had to make it "lie" to the client in order to deal with the subtleties of the INT 14h interface. For instance, because INT 14h's Subfunction 2 (Receive Character) waits a fixed amount of time for a character before giving up, communications programs usually call Subfunction 3 (Get Status) first to confirm that a character is present. However, although the non–interrupt-driven BIOS can read two UART registers and report them verbatim as the status, the interrupt-driven server can't. (It's constantly clearing characters out of the UART in response to interrupt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```
  {Initialize NCBs for the conversation}
  clientSendBlock.Init(SEND);
  clientRcvBlock.Init(RECEIVE);
  end; {Connect}

procedure Int14Handler(flags,cs,ip,ax,bx,cx,dx,si,di,ds,es,bp : Word);
  interrupt;
  {All Int 14 requests are sent off to the server for processing.
   The server takes care of queueing, returning status, etc.
   Note that this code doesn't filter out invalid function codes;
   this allows us to add functionality at the server without
   changing the basic client.}
  var
    commRegs : CommRegType absolute dx;
  begin
  if dx <> biosPortNum then {Chain to old vector}
    asm
    mov sp,bp
    pop bp; pop es; pop ds; pop di; pop si;
    pop dx; pop cx; pop bx; pop ax;
    jmp oldInt14;
    end
  else
    begin
    asm sti end; {Turn on interrupts}
    with clientSendBlock do
      begin
      bufPtr := Addr(commRegs);
      lsn := commSessionNum;
      len := SizeOf(CommRegType);
      if ReturnCode = GOOD_RTN then
        with clientRcvBlock do
          begin
          bufPtr := Addr(commRegs); {Point to block with dx,cx,bx,ax}
          len := SizeOf(commRegs); {Four words long}
          lsn := commSessionNum;
          if (ReturnCode <> GOOD_RTN) or (len <> SizeOf(commRegs)) then
            commRegs.ah := retcode or ERRORFLAG; {Slip in NetBIOS
                                                  error code}
          end
      else {If send failed}
        commRegs.ah := retcode or ERRORFLAG;
      end
    end {case ah}
  end; {Int14Handler}

procedure DivertInt14;
  begin
  GetIntVec($14,oldInt14);
  SetIntVec($14,Addr(Int14Handler));
  end; {DivertInt14}

begin {Client}
ValidateParms; {Check and parse command line}
Connect;
DivertInt14; {Capture INT 14 so we can provide services}
SwapVectors; {Prepare to go resident}
Keep(0); {Go resident}
end. {Client}
```

LISTING 2

```
{*
** Communications Server Version 1.0                    May 1, 1991
**
** Copyright 1987,1988,1991 by L. Brett Glass, Systems Consultant
**
}

program Commserver;
{$M 8192,0,0} {Use 8K of stack, no heap}

uses NetBIOS,NetTools,DOS,CRT;

{BIOS list of UART base I/O addresses}

type
  PortNumType = 1..4; {We restrict comm port numbers to 1 thru 4
                       because that's what's in the BIOS table}
var
  biosPortTable : array[portNumType] of Word absolute $40:00;

{UART declarations}

{The following constants give the offsets of ports from
 the UART's base address}

const
  RBR = $0;     {Receiver Buffer Register}
  THR = $0;     {Transmit Holding Register}
  DLL = $0;     {Low byte of divisor}
  DLH = $1;     {High byte of divisor}
  IER = $1;     {Interrupt Enable Register}
  IIR = $2;     {Interrupt Identification Register}
  LCR = $3;     {Line Control Register}
  MCR = $4;     {Modem Control Register}
  LSR = $5;     {Line Status Register}

{The following table lists baud rates. It maps the codes used
 in the BIOS to divisors.}

const
  divisorTable : array[0..8] of Word = (
    {110} $417, {150}  $300, {300}  $180, {600} $0C0, {1200} $060,
    {2400} $030, {4800} $018, {9600} $00C, {19200} $006);

{The following constants are necessary for managing interrupts}

const
  OCW1  =  $21; {Port address of enable bits for 8259}
  OCW2  =  $20; {Port address for commands to 8259}
  NSEOI =  $20; {Nonspecific EOI command}

  {Bit to use to mask interrupts at 8259}
  intMask : array [PortNumType] of Byte = ($10,$08,$10,$08);

  {Vector numbers for ports}
  commIntVec : array [PortNumType] of Byte = (12,11,12,11);

{The following masks are useful to manipulate bits
  in the UART registers}
const
  ERBFI = $01;  {Mask to enable receive interrupts}
  THRE =  $20;  {Mask for THRE}
  DTR = $01;    {Mask for DTR}
  DLAB = $80;   {Mask for DLAB}
  RTS = $02;  {Mask for RTS}
  OUT2 = $08; {Mask for OUT2}

{The following constants are handy to intialize the UART}

const
  ONESTOP = $00;{Mask for 1 stop bit}
  NOPARITY = $00; {Mask for  no  parity}
  EIGHTBITS = $03;{Mask for 8 bits/char}

{The following constant is returned in ah to indicate that no chars
 are available during a read}

  ERRORBYTE = $80;
{The following byte is used to mask the line status on a successful
 read. Note that the uppermost bit isn't allowed through, since
 a successful read does not set the timeout bit.}

  READSTATUSMASK = $0F;

{The following byte is used to mask requests to change the serial
 port parameters.}

  CHARMASK = $1F;

{These constants determine the initial baud rate for the port,
 the size of the receive buffer, and other serial port parameters}

const
  INITIALBAUD = 4; {Start at 1200 baud when initializing}
  BUFFMAX = 255;  {Size of receive buffer -- should be 2^n - 1}

type
  CommRegType = record
    case Boolean of
      TRUE: (dx,cx,bx,ax : Word);
      FALSE: (dl,dh,cl,ch,bl,bh,al,ah : Byte);
    end;

var
  portName : NetName;     {Network name of serial port}
  portNameNum : Byte;     {Number of this name in local name table}
  portNum : PortNumType; {Serial port number}
  portBase : Word;        {Base address of UART}
```

continued

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```
  rcvBuff : array [0..BUFFMAX] of Byte; {Circular fall-out buffer}
  buffIn, buffOut : Integer; {Buffer head and tail pointers}
  oldIntVec : Pointer;   {Storage for old interrupt vector}
  commSessionNum : Byte; {Number of NetBIOS session}
  clientName : NetName;  {Name of client}

function HexStr(var num; byteCount : Byte) : String;
  const
    hexChars : array [0..$F] of Char = '0123456789ABCDEF';
  var
    numArray : array [Byte] of Byte absolute num; {Access bytes of num}
    tempStr : String; {Holds result}
    tempLen : Byte absolute tempStr; {Length of result}
  begin
  tempLen := 0;
  for byteCount := Pred(byteCount) downto 0 do {numArray is 0-based}
    tempStr := tempStr +                        {Add:    }
               hexChars[numArray[byteCount] shr 4]  + {Hi digit}
               hexChars[numArray[byteCount] and $F];  {Lo digit}
  HexStr := tempStr
  end; {HexStr}

procedure ValidateParms;
  var
    tempStr : String;
  begin
  if ParamCount <> 2 then
    begin
    Writeln('Usage: COMMSERVER <Network Name> <Port Number>');
    Writeln(' E.G.: COMMSERVER MyModem 2');
    Writeln('       Makes COM2: a networked communications port');
    Writeln('        with the name MyModem');
    Halt
    end;
  tempStr := ParamStr(1);
  if (Length(tempStr) = 0) or (Length(tempStr) > 16) then
    begin
    Writeln('Error: Serial port/modem name must be 1 to 16 characters');
    Halt
    end;
  FillChar(portName,SizeOf(portName),' ');
  Move(tempStr[1],portName[1],Length(tempStr));
  tempStr := ParamStr(2);
  if (Length(tempStr) <> 1) or (tempStr[1] < '1') or
    (tempStr[1] > '4') then
    begin
    Writeln('Error: Port number must be 1 through 4');
    Halt
    end;
  portNum := Ord(tempStr[1])-Ord('0');
  portBase := biosPortTable[portNum];
  if portBase = 0 then
    begin
    Writeln('Error: Port does not exist');
    Halt
    end;
  end; {ValidateParms}

procedure IntHandler; interrupt; {Received character ISR}
  begin
  asm sti end;
  buffIn := Succ(buffIn) and BUFFMAX;
  rcvBuff[buffIn] := Port[portBase+RBR];
  if buffIn = buffOut then {Queue is overflowing. Keep newest characters.}
    buffOut := Succ(buffOut) and BUFFMAX;
  Port[OCW2] := NSEOI
 end; {IntHandler}
```

continued

640K WINDOWS ROM LIM EMS HMA DOS 5.0 XMS BUFFERS UMB 386MAX 486SX DRIVERS 386SX NETWORKS TSRs PAGEFRAME IPX INITIALIZE RAM MEMORY BIOS CACHE VGA MOUSE 386 BLUEMAX 486 HIGH

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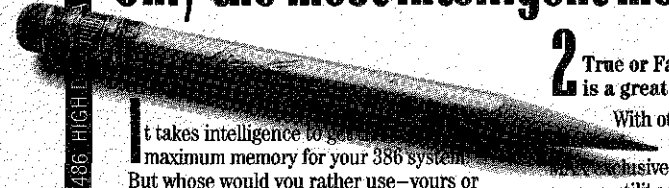

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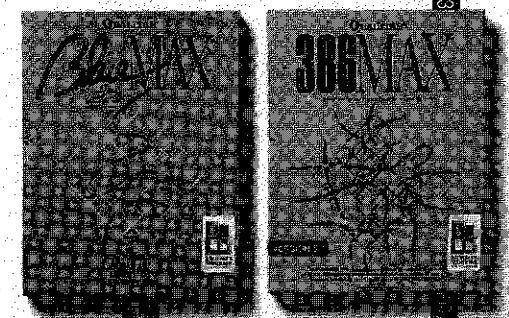

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requests, so those registers would never be able to show that a received character is available.) Thus, this server "fakes" the bit that indicates whether a character has come in. Also, to avoid delays, the server returns an "instant" timeout if it's asked to read an incoming character when none is present. Finally, the server doesn't use the handshaking sequences used by the BIOS. This allows it to work with modems that have carrier detection enabled and prevents conversations from being cut off when the BIOS drops DTR.

TIME FOR THE ACID TEST

After I got the client and server working with my small terminal program, I subjected them to the "acid test": a commercial communications package. I installed CrossTalk Mk4 (an expensive, powerful, and somewhat intimidating program) and connected its "INT14" driver to make it use the network. Mercifully, the program was able to call CompuServe and log in successfully. Cursor movement was sluggish, but I had no problems controlling the modem or downloading a file.

The performance of these initial attempts was acceptable—comparable to the free communications server software that came with my LAN package—but I'm convinced I can do better. Future experiments will include tricks such as sending characters to the client immediately (rather than waiting for requests) and transferring more than one character at a time in each direction. I'm also considering rewriting the client in assembly language and giving it a "client control panel" that will let it pick a port, disconnect from one, or uninstall itself on the fly.

The process of writing a communications server for modems was instructive, but a modem pool is a poor substitute for what most people really want: a good, fast modem on their desks. I'm looking forward to the day when I can create a communications server that connects to the outside world without using a modem at all. With the advent of ISDN, it should eventually be possible to make a server that hooks a LAN directly to the digital communications lines used by your phone. Imagine: no line noise, no busy signals, and a 64-kilobits/sec link to the outside world. Now *there's* a good reason to do communications over a LAN. PJ

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```
procedure InitPort;
  begin
  buffIn := 0;
  buffOut := 0;
  Port[portBase+IER] := 0;  {Disable comm interrupts first}

  {Hook into the interrupt vector}
  GetIntVec(commIntVec[portNum],oldIntVec);
  SetIntVec(commIntVec[portNum],Addr(IntHandler));

  {Initialize the UART}
  Port[portBase+LCR] := Port[portBase+LCR] or DLAB; {Access divisor latch}
  Port[portBase+DLL] := Lo(divisorTable[INITIALBAUD]); {Set baud rate
                                                        to 1200 }
  Port[portBase+DLH] := Hi(divisorTable[INITIALBAUD]);
  Port[portBase+LCR] := EIGHTBITS or ONESTOP or NOPARITY; {Clear DLAB and
                                                           set  parms}

  Port[portBase+MCR] := DTR or RTS or OUT2; {Enable interrupts, turn on
                                             DTR & RTS}

  {Turn  on  interrupts at the 8259}
  Port[OCW1] := Port[OCW1] and not(intMask[portNum]);
  if Port[portBase+LSR] <> 0 then; {Clear errors}
  if Port[portBase+RBR] <> 0 then; {Remove any trash in RBR}
  Port[portBase+IER] := ERBFI; {Enable UART receive interrupts}
  end; {InitPort}

procedure Shutdown;
  begin
  Port[portBase+IER] := 0; {Kill UART interrupts}
  Port[portBase+OCW1] := Port[portBase+ OCW1]
    or intMask[portNum]; {Mask interrupts at PIC}
  Port[portBase+MCR] := 0; {Shut off DTR, RTS, OUT2}
  SetIntVec(commIntVec[portNum],oldIntVec);
  if NetToolsDeleteName(portName) <> GOOD_RTN then; {Only try once}
  Writeln('Communcations server shutting down....');
  Halt;
  end; {Shutdown}

function UserAbort : Boolean;
  begin
  UserAbort := FALSE;
  if KeyPressed then
    case ReadKey of
      #3 : UserAbort := TRUE;
      #0 : if KeyPressed then
        UserAbort := (ReadKey = #0)
    end;
  end; {UserAbort}

procedure AwaitClient;
  var
    listenBlock : NCB;

  procedure ListenError;
    begin
    Writeln('Error: NetBIOS error when listening for clients');
    Shutdown
    end; {ListenError}

  begin
  case NetToolsStartListen(listenBlock,wildName,portName,10,10) of
    GOOD_RTN,COMMAND_PENDING:;
  else
    ListenError
  end;
  while TRUE do
```

continued

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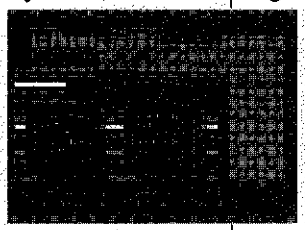

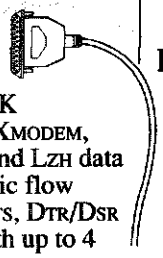

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```
    begin
    if UserAbort then
      begin
      NetToolsAbortListen(listenBlock);
      Shutdown
      end;
    case NetToolsCheckListen(listenBlock,commSessionNum,clientName) of
      GOOD_RTN : Exit;
      COMMAND_PENDING:;
    else
      ListenError
    end
    end;
  end; {AwaitClient}

function CharAvail : Boolean;
  begin
  asm cli end;
  CharAvail := (buffIn <> buffOut); {Do test with interrupts off}
  asm sti end;
  end; {CharAvail}

procedure HandleRequest(var commRegs : CommRegType);
  begin
  with commRegs do
    begin
    case ah of
      0: {Initialize comm port}
        begin
        Port[portBase+LCR] := Port[portBase+LCR] or DLAB; {Access divisor
                                                           latch}
        Port[portBase+DLL] := Lo(divisorTable[ah shr 5]); {Set baud rate}
        Port[portBase+DLH] := Hi(divisorTable[ah shr 5]);
        Port[portBase+LCR] := al and CHARMASK; {Set character parameters}
        ah := Port[portBase+LSR] or Byte(CharAvail);
        al := Port[portBase+MCR]; {Return modem status}
        end;
      1: {Send character}
        begin
        {Because the UART always runs, we wait at most one character time}
        repeat until (Port[portBase+LSR] and THRE) <> 0;
        Port[portBase+THR] := al;
        ah := Port[portBase+LSR] or Byte(CharAvail);
        end;
      2: {Receive character}
        begin
        if CharAvail then
          begin
          asm cli end; {Maintain consistency}
          buffOut := Succ(buffOut) and BUFFMAX;
          al := rcvBuff[buffOut];
          asm sti end; {Interrupts OK now}
          ah := (Port[portBase+LSR] or Byte(CharAvail)) and READSTATUSMASK;
          end
        else
          ah := ERRORBYTE;
        end;
      3: {Get Status}
        begin
        ah := Port[portBase+LSR] or Byte(CharAvail);
        al := Port[portBase+MCR]; {Return modem status}
        end;
      4: {Extended Initialize}
        begin
        if cl <= 8 then
          begin
          Port[portBase+LCR] := Port[portBase+LCR] or DLAB; {Access divisor
                                                             latch}
          Port[portBase+DLL] := Lo(divisorTable[cl]); {Set baud rate}
          Port[portBase+DLH] := Hi(divisorTable[cl]);
          end;
        Port[portBase+LCR] :=  ((al and 1) shr 6) {Break}
                             + ((bh and 3) shr 3) {Parity}
                             + ((bl and 1) shr 2) {Stop bits}
                             + ((ch + 1) and 3);  {Data bits}
        ah := Port[portBase+LSR] or Byte(CharAvail);
        al := Port[portBase+MCR]; {Return modem status}
        end;
      5: {Modem Control}
        begin
        if al = 1 then
          begin
          Port[portBase+MCR] := bl;
          ah := Port[portBase+LSR] or Byte(CharAvail);
          al := Port[portBase+MCR]; {Return modem status}
          end
        else
          bl := Port[portBase+MCR];
        end;
      end; {case}
    end; {with}
  end; {HandleRequest}

procedure FieldRequests;
  var
    serverRcvBlock, serverSendBlock : NCB;
    commRegs : CommRegType;
  begin
  serverRcvBlock.Init(RECEIVE);
  serverSendBlock.Init(SEND);
  while TRUE do
    begin
    with serverRcvBlock do
      begin
      len := SizeOf(commRegs);
      bufPtr := Addr(commRegs);
      lsn := commSessionNum;
      case serverRcvBlock.ReturnCode of
        TIMEOUT: if UserAbort then
          begin
          if NetToolsHangup(commSessionNum) <> GOOD_RTN then;
          Shutdown
          end;
        ILL_SESSION,SESSION_ABEND: {These mean session over}
          begin
          Writeln('Session aborted');
          Exit;
          end;
        SESSION_CLOSED:
          begin
          Writeln('Client closed session');
          Exit;
          end;
        GOOD_RTN:
          begin
          if len <> SizeOf(commRegs) then {Kill session if bad packet}
            begin
            if NetToolsHangup(commSessionNum) <> GOOD_RTN then;
            Exit
            end;
          HandleRequest(commRegs);
          with serverSendBlock do
            begin
            bufPtr := Addr(commRegs);
            len := SizeOf(commRegs);
            lsn := commSessionNum;
            if ReturnCode <> GOOD_RTN then
              Exit; {Session dead if send didn't complete}
            end
          end
        end {case}
      end {with}
    end {while}
  end; {FieldRequests}

begin {CommServer}
CheckBreak := FALSE;
DirectVideo := TRUE;
Writeln('CommServer V1.00, Copyright 1991 by L. Brett Glass');
ValidateParms;
if not NetBIOSPresent then
  begin
  Writeln('Error: NetBIOS not present');
  Halt
  end;
if NetToolsAddUniqueName(portName,portNameNum) <> GOOD_RTN then
  begin
  Writeln('Error: Could not register port name');
  Halt
  end;
InitPort;
while TRUE do
  begin
  Writeln('Awaiting a client...');
  AwaitClient;
  Writeln('Connection established with client ', HexStr(clientName,16));
  FieldRequests;
  Writeln('End of session');
  end;
end.
```


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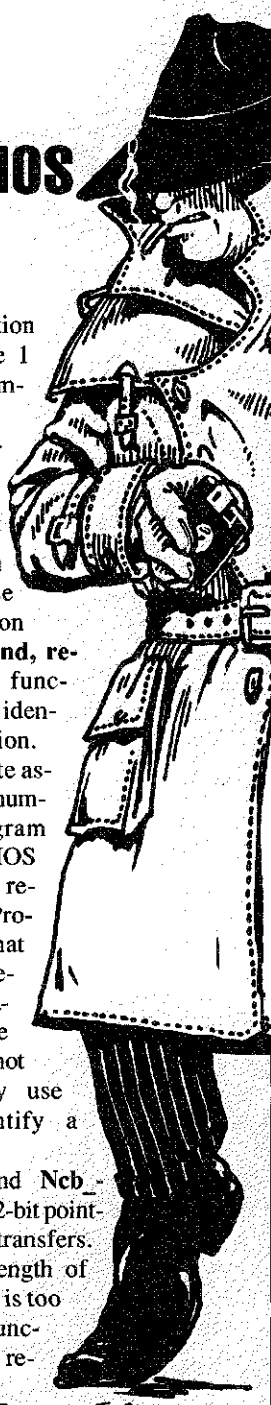
Spying on NetBIOS

Assembly language routines to access NetBIOS datagrams and a snooping utility



By John Otken

NetBIOS—a network interface for DOS programs—permits two or more computers to exchange data quickly and reliably. A common use for NetBIOS is to transfer files among machines. Because NetBIOS is a software (not a hardware) specification, the same program should work over almost any kind of network. NetBIOS drivers exist for Ethernet, Arcnet, and Token Ring.

NetBIOS has two types of data transfer services: datagrams and sessions. *Datagrams* are useful for sending small amounts of information when it's not important to control or confirm its receipt. Some networks use datagrams to announce the time, which can help keep computer clocks synchronized. Datagrams are like postcards: you don't know whether or not the addressee receives them, and they don't necessarily arrive in the order they were sent.

A network *session* is similar to a connection between two error-correcting modems. Data can be reliably transferred in either direction, and you will know whether the connection is successful. For operations such as file transfers, sessions are preferable to datagrams.

John Otken is president of Soft Advances, where he hacks assembly language into debuggers and develops other software for embedded systems. He can be contacted by writing to him at P.O. Box 184, Orinda, CA 94563.

PLAYING THE FIELDS

Except for data buffers, all program communication with the NetBIOS driver passes through a 64-byte data structure known as the NetBIOS Control Block (NCB). The NCB has 14 fields (Figure 1). Most NetBIOS functions use only a few fields on entry to the driver, and a few more on exit. Descriptions of the fields follow.

The **Ncb_Command** byte holds the 7-bit NetBIOS function code. The most significant bit of this location is the wait option. When the wait bit is 0, the driver completes the NetBIOS function before returning to the program. When the wait bit is 1, the driver returns to the program before the function completes: the NCB is still active, and the driver updates the other fields of the NCB as the network function executes. More than one NCB can be active simultaneously.

The **Ncb_RetCode** byte holds the final return code for a NetBIOS function. While a network function is in progress, this field is 0xFF. After a function completes, the driver sets the return code in both **Ncb_RetCode** and **Ncb_Cmd_Cplt.** Programs should use **Ncb_Cmd_Cplt** (not **Ncb_RetCode**) to detect when a function has completed. Table 1 (p. 51) lists some common return codes.

Ncb_Lsn is a 1-byte local session number. The NetBIOS **call** and **listen** functions exit with this value. Because more than one session can be active, the **send, receive,** and **hang up** functions use **Ncb_Lsn** to identify the intended session.

The **Ncb_Num** byte associates a local name number with the datagram functions. The NetBIOS **add name** function returns this number. Programs must ensure that this field is valid before using any datagram functions. The session functions do not use this field; they use **Ncb_Name** to identify a local process.

Ncb_BufferOff and **Ncb_BufferSeg** contain a 32-bit pointer to a buffer for data transfers. **Ncb_Length** is the length of that buffer. If a buffer is too small for a **receive** function, the driver sets a return code of 0x06.

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LISTING 1

```
   ***NOTE: minor edits have been made in order to conserve space.-Ed.***

; netbios.inc

;
; NetBIOS command codes
;
NB_CALL_WAIT                    equ  10h
NB_CALL                         equ  90h
NB_LISTEN_WAIT                  equ  11h
NB_LISTEN                       equ  91h
NB_HANG_UP_WAIT                 equ  12h
NB_HANG_UP                      equ  92h
NB_SEND_WAIT                    equ  14h
NB_SEND                         equ  94h
NB_RECEIVE_WAIT                 equ  15h
NB_RECEIVE                      equ  95h
NB_SEND_DATAGRAM_WAIT           equ  20h
NB_SEND_DATAGRAM                equ 0A0h
NB_RECEIVE_DATAGRAM_WAIT        equ  21h
NB_RECEIVE_DATAGRAM             equ 0A1h
NB_SEND_BROADCAST_WAIT          equ  22h
NB_SEND_BROADCAST               equ 0A2h
NB_RECEIVE_BROADCAST_WAIT       equ  23h
NB_RECEIVE_BROADCAST            equ 0A3h
NB_ADD_NAME_WAIT                equ  30h
NB_ADD_NAME                     equ 0B0h
NB_DELETE_NAME_WAIT             equ  31h
NB_DELETE_NAME                  equ 0B1h
NB_RESET                        equ  32h
NB_CANCEL                       equ  35h
NB_ADD_GROUP_NAME_WAIT          equ  36h
NB_ADD_GROUP_NAME               equ 0B6h

NB_INVALID_COMMAND              equ  7Fh

DATAGRAM_MAX            equ     512     ; maximum length of a datagram
OK_RetCode              equ     0

;
; NetBIOS Command Block
;
ncb     struc
  Ncb_Command           db      ?       ; command (function) code
  Ncb_RetCode           db      ?       ; return code or 0xFF if pending
  Ncb_Lsn               db      ?       ; local session number
  Ncb_Num               db      ?       ; name number returned by AddName
  Ncb_BufferOff         dw      ?       ; message buffer offset
  Ncb_BufferSeg         dw      ?       ; message buffer segment
  Ncb_Length            dw      ?       ; message buffer length
  Ncb_CallName          db  16 dup(?)   ; remote name
  Ncb_Name              db  16 dup(?)   ; local name (see AddName)
  Ncb_Rto               db      ?       ; receive timeout
  Ncb_Sto               db      ?       ; send timeout
  Ncb_PostOff           dw      ?       ; pointer to procedure to execute
  Ncb_PostSeg           dw      ?       ; when nowait function completes
  Ncb_Lana_Num          db      ?       ; 0 primary adapter, 1 secondary
  Ncb_Cmd_Cplt          db      ?       ; 0 when nowait function completes
  Ncb_Reserved          db  14 dup(?)   ; reserved for use by NetBIOS
ncb     ends
; member names from "C Programmer's Guide to NetBIOS" by WDS

                                        ; end of netbios.inc
```

LISTING 2

```
; net_misc.asm
        title   NetBIOS Miscellaneous
        include asm.inc
        include netbios.inc

        public  clear_ncb, public  netbios_add_name
        public  netbios_call, public  netbios_cancel
        public  netbios_check, public  netbios_delete_name
        public  netbios_hang_up, public  netbios_receive_wait
        public  netbios_send_broadcast, netbios_send_datagram
        public  netbios_send_wait, public  put_netbios_name

        .data?

temp_ncb ncb    <>      ; netbios control block for temporary use

        .code

        extn    putchar,strncpy,save_most

;;      clear ncb
;
;       entry   DS:SI   ncb ptr
;
clear_ncb proc
        pushm   ax,cx,di,es
        mov     ax,ds
        mov     es,ax
        mov     di,si
        xor     ax,ax
        mov     cx,size ncb
        rep     stosb
        popm    es,di,cx,ax
        ret
clear_ncb endp

;;      netbios add name
;
;       entry   DS:SI   asciiz name (less than 16 characters long)
;       exit    Cf      if error
;               AL      name number (or return code if error)
netbios_add_name proc
        call    save_most
        call    zero_temp_ncb           ; copy name to control block
        call    write_temp_ncb
        lea     di,Ncb_Name[di]
        mov     cx,size Ncb_Name+1      ;  (+1 is for \0, OK to overflow \0
        call    strncpy                 ;   into next field)

        call    read_temp_ncb
        mov     Ncb_Command[si],NB_ADD_NAME_WAIT
        call    netbios_call
        jc      nan1                    ;  if error

        mov     al,Ncb_Num[si]
nan1:   ret
netbios_add_name endp

;;      netbios call
;
;       entry   DS:SI   netbios control block
;       exit    AX      return code (0xFF if function pending)
;               Cf      if error
; netbios_call proc
        push    es
        mov     ax,ds                   ; call NetBIOS
        mov     es,ax                   ;  ES:BX points to control block
        xchg    bx,si
        int     5Ch
        xchg    bx,si

        mov     al,Ncb_Cmd_Cplt[si]     ; get return code
        and     ax,0FFh                 ;  (AH=0)
        jz      ncb1                    ;  if successful completion (Cf==0)

        cmp     al,0FFh                 ; set Cf if error (AL!=0xFF)

ncb1:   pop     es
        ret
netbios_call endp

;;      netbios cancel
;
;       entry   DS:SI   netbios command block
;       exit    AX      final return code
;               Cf      if error
netbios_cancel proc
        pushm   si,ds
        pushm   si,ds                   ; (push again, pop into NCB below)

        call    read_temp_ncb           ; clear control block
        call    clear_ncb

        pop     Ncb_BufferSeg[si]       ; set control block fields
        pop     Ncb_BufferOff[si]
        mov     Ncb_Command[si],NB_CANCEL

        call    netbios_call
        popm    ds,si
        ret
netbios_cancel endp

;;      netbios check
```

continued

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The 16-byte **Ncb_CallName** field holds the name of the remote process for sessions and datagrams. A program sets this field on entry to **call, listen,** or **send** datagram functions. Both **receive** datagram functions set this field. A program can use the special name "*" to listen for a call from any process.

The 16-byte **Ncb_Name** field holds the local process name for the **call, listen, add name,** and **delete name** functions. The datagram functions do not use this field; they use **Ncb_Num.** Programs must register names using the **add name** function before a call or a listen.

The **Ncb_Rto** and **Ncb_Sto** bytes hold the session **receive** and **send** timeout values in half-second intervals. A value of 0 disables timeouts. These fields are valid on **call** and **listen** functions only.

Ncb_PostOff and **Ncb_PostSeg** contain a pointer to a postprocessing procedure. When a function completes, the driver invokes the routine at this address. On entry, register AL has the final return code, and ES:BX points to the NCB. **Ncb_Cmd_Cplt** is still 0xFF. The procedure should process the function and return to the driver with an IRET; it should not make any calls to DOS, and it does not have to save registers. The NetBIOS driver ignores this field if it is 0 or if the wait bit of **Ncb_Command** is 0 (wait-enabled).

On systems that have multiple network adapter cards, **Ncb_Lana_Num** selects the card to associate with an NCB. On most systems, this field is 0.

The **Ncb_Cmd_Cplt** field holds the final return code for NetBIOS functions. It is identical to **Ncb_RetCode** except that the driver does not set this field until after it has executed the **Ncb_Post** procedure. Programs should use this field to detect when a function completes.

The 14-byte **Ncb_Reserved** field is reserved for the NetBIOS driver. Programs should not manipulate this field.

FIGURE 1: The NetBIOS control block

```
Ncb_Command     db      ?           ; function code
Ncb_RetCode     db      ?           ; return code
Ncb_Lsn         db      ?           ; local session number
Ncb_Num         db      ?           ; local name number
Ncb_BufferOff   dw      ?           ; data buffer offset
Ncb_BufferSeg   dw      ?           ; data buffer segment
Ncb_Length      dw      ?           ; data buffer length
Ncb_CallName    db 16 dup(?)        ; remote process name
Ncb_Name        db 16 dup(?)        ; local process name
Ncb_Rto         db      ?           ; receiver time out
Ncb_Sto         db      ?           ; sender time out
Ncb_PostOff     dw      ?           ; post proc offset
Ncb_PostSeg     dw      ?           ; post proc segment
Ncb_Lana_Num    db      ?           ; adapter number
                                    ;  (usually 0)
Ncb_Cmd_Cplt    db      ?           ; command complete
                                    ;  flag
Ncb_Reserved    db 14 dup(?)        ; reserved for driver
```

LOOKING FOR MR. NETBIOS

NetBIOS is an optional part of a computer's system software. Before executing any functions, a program should check for the presence of a NetBIOS driver. Sample code for this

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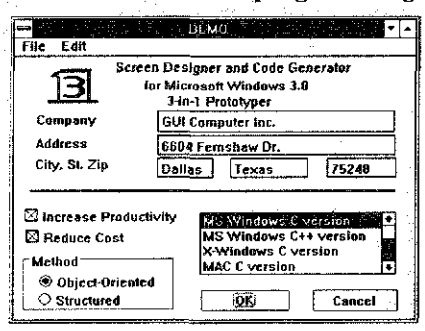

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operation appears in the procedure **netbios_check.** Because old IBM PCs zero unused interrupt vectors, this routine first ensures that the vector for interrupt 0x5C is nonzero. Then **netbios_check** will execute an illegal NetBIOS function, and if the function returns an error, then a NetBIOS driver is present.

A program controls a network by building a NetBIOS control block and invoking the driver through interrupt 0x5C. On entry to the driver, registers ES:BX point to the NCB. The driver exits with a return code in AL, leaving the other registers unchanged. The only field required for all NetBIOS functions is a code in **Ncb_Command.**

NETBIOS FUNCTIONS

NetBIOS has 21 different functions; 18 of them accept the wait option, and the other 3 always wait for a function to complete.

The sample programs use 12 functions, described below. Table 2 summarizes the entry and exit conditions for these functions.

```
;
;       exit    Cf      if no netbios driver
;       uses    AX,SI
netbios_check proc
        push    ds                      ; check if vector 5C is zero
        mov     ax,0
        mov     ds,ax
        mov     si,4*5Ch
        lds     si,[si]                 ;  (this faults in protect mode)
        mov     ax,ds
        or      ax,si
        jz      nbcl                    ;  if no NetBIOS driver (Cf==0)

        call    read_temp_ncb
        call    clear_ncb
        mov     Ncb_Command[si],NB_INVALID_COMMAND
        call    netbios_call

nbcl:   cmc                             ; flip error flag
        pop     ds
        ret
netbios_check endp

;;      netbios delete name
;
;       entry   DS:SI   asciiz name (less than 16 characters long)
;       exit    Cf      if error
;               AL      return code
netbios_delete_name proc
        call    save_most
        call    zero_temp_ncb           ; copy name to control block
        call    write_temp_ncb
        lea     di,Ncb_Name[di]
        mov     cx,size Ncb_Name+1      ;  (+1 is for \0, OK to overflow
\0      call    strncpy                 ;   into next field)

        call    read_temp_ncb
        mov     Ncb_Command[si],NB_DELETE_NAME_WAIT
        call    netbios_call
        ret
netbios_delete_name endp

;;      netbios hang up
;
;       entry   AL      session number
;       exit    AL      return code
;               Cf      if error
netbios_hang_up proc
        pushm   si,ds
        call    read_temp_ncb
        call    zero_temp_ncb
        mov     Ncb_Lsn[si],al
        mov     Ncb_Command[si],NB_HANG_UP_WAIT
        call    netbios_call
        popm    ds,si
        ret
netbios_hang_up endp

;;      netbios receive wait
;
;       entry   AL      local session number
;               CX      buffer length
;               ES:DI   buffer pointer
;       exit    AL      return code
;               CX      bytes received (0 if session closed or error)
;               Cf      if error (session closed is not an error)
netbios_receive_wait proc
        pushm   si,ds
        call    read_temp_ncb
        call    zero_temp_ncb
        mov     Ncb_Lsn[si],al
        mov     Ncb_Length[si],cx
        mov     Ncb_BufferOff[si],di
        mov     Ncb_BufferSeg[si],es

        mov     Ncb_Command[si],NB_RECEIVE_WAIT

        call    netbios_call
        jnc     nrw1                    ; if receive OK

        mov     cx,0                    ; else check return code
        cmp     al,0Ah
        je      nrw2                    ;  if session closed, then no error
        stc                             ;  else return error
        jmp     nrw2

nrw1:   mov     cx,Ncb_Length[si]
nrw2:   popm    ds,si
        ret
netbios_receive_wait endp

;;      netbios send broadcast
;
;       entry   AL      add name number
;               CX      buffer length
;               ES:DI   buffer
;       exit    AL      return code
;               Cf      if error
;       note    waits until datagram sent over network
netbios_send_broadcast proc
        pushm   si,ds
        call    read_temp_ncb
        call    clear_ncb
        mov     Ncb_Num[si],al
        mov     Ncb_Length[si],cx
        mov     Ncb_BufferOff[si],di
        mov     Ncb_BufferSeg[si],es
        mov     Ncb_Command[si],NB_SEND_BROADCAST_WAIT
        call    netbios_call
        popm    ds,si
        ret
netbios_send_broadcast endp

;;      netbios send datagram
;
;       entry   AL      add name number
;               CX      buffer length
;               ES:DI   buffer
;               DS:SI   asciiz call name (destination)
;       exit    AL      return code
;               Cf      if error
;       note    waits until datagram sent over network
netbios_send_datagram proc
        call    save_most               ; initialize datagram control block
        pushm   ds,si
        call    zero_temp_ncb
        call    read_temp_ncb
        mov     Ncb_Num[si],al          ;  set "add name" number,
        mov     Ncb_Length[si],cx       ;   buffer length and pointer
        mov     Ncb_BufferOff[si],di
        mov     Ncb_BufferSeg[si],es
        popm    si,ds

        call    write_temp_ncb          ; copy destination name into block
        lea     di,Ncb_CallName[di]
        mov     cx,size Ncb_CallName+1
        call    strncpy

        call    read_temp_ncb           ; send datagram and wait
        mov     Ncb_Command[si],NB_SEND_DATAGRAM_WAIT
```

continued

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```
        call    netbios_call
        ret
netbios_send_datagram endp

;;      netbios send wait
;
;       entry   AL      session number
;               CX      length
;               ES:DI   buffer pointer
;       exit    AL      return code
;               Cf      if error
netbios_send_wait proc
        pushm   si,ds
        call    read_temp_ncb
        call    zero_temp_ncb

        mov     Ncb_Lsn[si],al
        mov     Ncb_Length[si],cx
        mov     Ncb_BufferOff[si],di
        mov     Ncb_BufferSeg[si],es

        mov     Ncb_Command[si],NB_SEND_WAIT
        call    netbios_call
        popm    ds,si
        ret
netbios_send_wait endp

;;      put netbios name
;
;       entry   DS:SI   name field of control block
;       uses    AX,SI
put_netbios_name proc
        push    cx
        mov     cx,size Ncb_CallName
pnn1:   lodsb
        cmp     al,' '
        jbe     pnn2
        cmp     al,'~'
        jbe     pnn3
pnn2:   mov     al,' '
pnn3:   call    putchar
        loop    pnn1
        pop     cx
        ret
put_netbios_name endp

;;      read temp ncb
;
;       exit    DS:SI   temporary netbios control block
read_temp_ncb proc
        mov     si,@data
        mov     ds,si
        lea     si,temp_ncb
        ret
read_temp_ncb endp

;;      write temp ncb  ;
;       exit    ES:DI   temporary netbios control block
write_temp_ncb proc
        mov     di,@data
        mov     es,di
        lea     di,temp_ncb
        ret
write_temp_ncb endp

;;      zero temp ncb
zero_temp_ncb proc
        pushm   ax,si,ds
        call    read_temp_ncb
        call    clear_ncb
        popm    ds,si,ax
        ret
zero_temp_ncb endp
        end
```

LISTING 3

```
; datagram.asm
        title   send datagram
        include asm.inc
        include netbios.inc

        public  main

        .stack

        .const
add_name_text   db      'Send Datagram',0

broadcast_text  db      'Broadcast '
datagram_text   db      'Datagram sent.',0

help_text       label   byte
  db  'datagram <target> <text>',13,10
  db  'Sends <text> in NetBIOS datagram to <target>.',13,10
  db  'Use * to broadcast datagram.',13,10
  db  'e.g.: datagram TEST This is a datagram to remote name TEST.',13,10
  db  'e.g.: datagram * This is a broadcast datagram.',0

driver_ertx     db      'No NetBIOS driver found',0
add_name_ertx   db      'Add Name failed',0

        .data?
        extrn   argc:word,argv:dword

add_name db     ?

        .code
        extn    startup,puts,exit_program,netbios_check,netbios_add_name
        extn    strskp_white,read_command_line,netbios_send_datagram
        extn    netbios_send_broadcast,netbios_delete_name

;;      help
;
;       entry   DS      DGROUP
help    proc
        lea     si,help_text
        call    puts
        jmp     exit_program
help    endp

;;      main
;
main    proc
        cmp     argc[bp],2
        jb      help                    ;  if no arguments

        call    netbios_check
        jc      mai5                    ;  if no netbios driver

        lea     si,add_name_text        ; *Send Datagram*
        call    netbios_add_name
        jc      mai6                    ;  if add name failed
        mov     add_name[bp],al

        call    read_command_line       ; find <text> in command line
        call    strskp_white
mai1:   lodsb                           ;  skip <target>
        cmp     al,' '
        ja      mai1

        dec     si                      ;  skip space between <target>&<text>
        call    strskp_white

        mov     di,si                   ;  ES:DI points to <text>
        mov     ax,ds
        mov     es,ax
        mov     cx,-1                   ; compute length of <text>
mai2:   inc     cx
        lodsb
        cmp     al,' '                  ;  (any control char is delimiter)
        jae     mai2                    ;  if delimiter

        mov     al,add_name[bp]

        lds     si,argv[bp]
        mov     si,[si+2]
        cmp     word ptr [si],'*'
        je      mai3                    ;  if broadcast datagram

        call    netbios_send_datagram   ;  else send normal datagram
        lea     si,datagram_text
        jmp     mai4

mai3:   call    netbios_send_broadcast
        lea     si,broadcast_text
mai4:   mov     ax,@data
        mov     ds,ax
        call    puts
        lea     si,add_name_text
```

continued

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```
        call    netbios_delete_name
        jmp     exit_program

mai5:   lea     si,driver_ertx          ; *No NetBIOS driver found*
        call    puts
        jmp     exit_program

mai6:   lea     si,add_name_ertx        ; *Add Name failed*
        call    puts
        jmp     exit_program
main    endp

        end
```

LISTING 4

```
; spy.asm
        title   netbios datagram spy
        include asm.inc
        include netbios.inc

        public  main

        .stack

        .const
broadcast_text  db  'Broadcast',0
callname_text   db  ' - Call Name:',0
datagram_text   db  'Datagram ',0
driver_text     db  'No NetBIOS driver found',0
help_text       db  'NetBIOS Spy - displays network datagrams',13,10
                db  'Press ESC to exit',0
length_text     db  ' - Length:',0
retcode_text    db  ' - RetCode:',0
spy_text        db  'Spy',0

        .data?
ncb_broadcast   ncb <>                  ; control blk for broadcast
datagrams
ncb_datagram    ncb <>                  ; control blk for other datagrams

buf_broadcast   db  DATAGRAM_MAX dup(?) ; buffer for broadcast datagrams
buf_datagram    db  DATAGRAM_MAX dup(?) ; buffer for other datagrams

add_name db     ?

        .code
 extrn exit_program,get_input_state,clear_ncb,netbios_call,netbios_cancel
 extrn putchar_newline,puts,put_hex_byte,put_hex_word,put_multiple_bytes
 extrn put_netbios_name,put_string,startup,netbios_check
 extrn netbios_add_name,netbios_delete_name

;;      main
;
main    proc
        lea     si,help_text
        call    puts

        call    netbios_check
        jc      mai4                    ;  if no netbios driver

        lea     si,spy_text
        call    netbios_add_name
        mov     add_name[bp],al
mai1:   lea     si,ncb_broadcast        ; check receive broadcast datagram
        cmp     Ncb_Cmd_Cplt[si],0FFh
        je      mai2                    ;  if receive pending

        call    clear_ncb               ;  else post receive broadcast
        mov     Ncb_Command[si],NB_RECEIVE_BROADCAST
        mov     Ncb_Num[si],0FFh        ;  (FF means any datagram)
        mov     Ncb_BufferOff[si],offset buf_broadcast
        mov     Ncb_BufferSeg[si],ds
        mov     Ncb_Length[si],size buf_broadcast
        call    netbios_call

mai2:   lea     si,ncb_datagram         ; check receive datagram
        cmp     Ncb_Cmd_Cplt[si],0FFh
        je      mai3                    ;  if receive pending

        call    clear_ncb               ;  else post receive broadcast
        mov     Ncb_Command[si],NB_RECEIVE_DATAGRAM
        mov     al,0FFh                 ;  (FF means any datagram)
        mov     al,add_name[bp]
        mov     Ncb_Num[si],al
        mov     Ncb_BufferOff[si],offset buf_datagram
        mov     Ncb_BufferSeg[si],ds
        mov     Ncb_Length[si],size buf_datagram
        call    netbios_call

mai3:   call    get_input_state
        jnz     mai5                    ;  if key waiting

        lea     si,ncb_broadcast
        call    process_control_block

        lea     si,ncb_datagram
        call    process_control_block
        jmp     mai1

mai4:   lea     si,driver_text          ; *No NetBIOS driver found*
        call    puts
        jmp     exit_program
mai5:   lea     si,ncb_broadcast
        call    netbios_cancel
        lea     si,ncb_datagram
        call    netbios_cancel
        lea     si,spy_text
        call    netbios_delete_name
        jmp     exit_program
main    endp

;;      process control block
;
;       entry   DS:SI   datagram control block
;       uses    AX,BX,CX,SI
process_control_block proc
        mov     bx,si
        cmp     Ncb_Cmd_Cplt[bx],0FFh
        je      pcb3                    ;  if receive still pending
        lea     si,datagram_text        ; *Datagram *
        cmp     Ncb_Command[bx],NB_RECEIVE_DATAGRAM
        je      pcb1
        lea     si,broadcast_text       ; *Broadcast*
pcb1:   call    put_string

        cmp     Ncb_RetCode[bx],0       ; display non-zero return code
        je      pcb2

        lea     si,retcode_text         ; * - RetCode:*
        call    put_string
        mov     al,Ncb_RetCode[bx]
        call    put_hex_byte

pcb2:   lea     si,length_text          ; * - Length:*
        call    put_string
        mov     ax,Ncb_Length[bx]
        call    put_hex_word

        lea     si,callname_text        ; * - Call Name:*
        call    put_string

        lea     si,Ncb_CallName[bx]     ; display call name
        call    put_netbios_name
        call    putchar_newline

        push    ds                      ; display datagram
        mov     cx,Ncb_Length[bx]
        lds     si,dword ptr Ncb_BufferOff[bx]
        call    put_multiple_bytes
        pop     ds
pcb3:   ret
process_control_block endp

        end
```

LISTING 5

```
; server.asm
        title   simple file server
        include asm.inc
        include netbios.inc

        public  main

        .stack

        .const
ertx_add_name           db  'Add Name error',0
ertx_driver             db  'No NetBIOS driver',0
```

continued

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The ADD NAME function registers a name into the NetBIOS local name table and returns a local name number. The name must be unique across the network. To register a name, a program fills the name into the **Ncb_Name** field, sets the **Ncb_Command** code, and calls the NetBIOS driver. Names are always 16 bytes long. NetBIOS does not use null terminating bytes (as in C), nor does it use string lengths (as in Pascal).

The driver returns a numeric identifier for the name in the **Ncb_Num** field; use this number with the various datagram functions. Because this function must wait for possible replies from other systems on the network, it can take several seconds to complete. Programs should delete names before they exit.

The CALL function opens a full duplex session with another process on the network. The entry conditions for CALL require a target name in the **Ncb_CallName** field, a registered local name in **Ncb_Name,** and timeout values in **Ncb_Rto** and **Ncb_Sto.** If another process has a LISTEN posted with the matching names, the CALL function returns a local session number in **Ncb_Lsn.**

The CANCEL function aborts a pending NetBIOS function. CANCEL cannot abort a waiting function, nor can it abort the ADD NAME, DELETE NAME, SEND DATAGRAM, or SEND BROADCAST DATAGRAM functions. This operation is usually used on a pending **receive** or **listen** function. On entry to CANCEL, the address of the target NCB is in **Ncb_BufferOff** and **Ncb_BufferSeg.**

DELETE NAME removes a 16-character name from a NetBIOS local name table. Before deleting a name, a program should cancel functions or terminate sessions that use the name. If a session is active, NetBIOS can defer a **delete** operation, but error detection and recovery become more complex.

HANG UP closes the session identified by the local session number in **Ncb_Lsn.** Either side can close a session, but it is usually easier to let the sending side do so. A HANG UP at either end closes the session for both ends. When a session closes, a pending **send** function completes, but a pending **receive** function returns 0x0A in its **Ncb_RetCode** field.

The LISTEN function opens a session with a corresponding CALL function. Entry conditions for LISTEN require a target name in the **Ncb_CallName** field, a registered local name in **Ncb_Name,** and timeout values in **Ncb_Rto** and **Ncb_Sto.** NetBIOS establishes a session between the CALL and LISTEN functions when the **Ncb_Name** fields of both sides match the **Ncb_CallName** fields of the other. The LISTEN function can use the special wildcard name "*" to match any calling **Ncb_Name** field. As with CALL, the **Ncb_Name** field must be registered with ADD NAME. When a session opens, NetBIOS puts a local session number in **Ncb_Lsn.**

The RECEIVE function accepts data from a session partner. Entry conditions require a local session number in **Ncb_Lsn** and a buffer specification in **Ncb_BufferOff, Ncb_BufferSeg,** and **Ncb_Length.** If the receiving buffer is too small, NetBIOS fills the buffer and returns a code of 0x06. The program must post another RECEIVE function to transfer the rest of the data. If a session closes, active RECEIVE functions set **Ncb_RetCode** to 0x0A. On exit, **Ncb_Length** holds the number of bytes transferred.

RECEIVE BROADCAST DATAGRAM accepts datagrams from any process that issues a SEND BROADCAST DATAGRAM. Entry conditions require a valid local name number in **Ncb_Num** and a buffer specification in **Ncb_BufferOff, Ncb_BufferSeg,** and **Ncb_Length.** If the buffer is too small, the function code is 0x06, and the remaining data is lost. On exit, **Ncb_Length** holds the number of bytes that were sent.

RECEIVE DATAGRAM accepts a datagram message from a matching SEND DATAGRAM. The sending **Ncb_CallName** field must match the name that corresponds to the **Ncb_Num** field of the receiver. The receiver can use the wildcard value 0xFF to match any locally registered name. The key word here is "registered"; a program is not able to receive all possible datagrams because it cannot register all possible names. As with all **receive** functions, the program must specify a buffer.

The SEND function transfers data to

TABLE 1: Common NetBIOS return codes

00h	Function complete, no errors
01h	Invalid buffer length
03h	Invalid command
05h	Function timeout
06h	Incomplete receive message (buffer too small)
08h	Bad local session number
0Ah	Session closed
0Bh	Command canceled
0Dh	Duplicate name in local name table
0Eh	Name table full
0Fh	Name deleted with sessions active
11h	Local session table full
15h	Name not found or invalid
16h	Name in use on remote
18h	Session ended abnormally
19h	Name conflict detected
FFh	Command pending

TABLE 2: Entry and exit conditions for some NetBIOS functions

Function	Command Code	Return Code	Local Sessn	Name Num	Mssg Buffer	Buffer Length	Remote Name	Call Name	-Timeouts- Recv	Send
ADD NAME	30h/B0h	Out		Out			In			
CALL	10h/90h	Out	Out				In	In	In	In
CANCEL	35h	Out			In					
DELETE NAME	31h/B1h	Out						In		
HANG UP	12h/92h	Out	In							
LISTEN	11h/91h	Out	Out				In*	In	In	In
RECEIVE	15h/95h	Out	In		In	In/Out				
RECEIVE BROADCAST DATAGRAM	23h/A3h	Out		In**	In	In/Out	Out			
RECEIVE DATAGRAM	21h/A1h	Out		In	In	In/Out	Out			
SEND	14h/94h	Out	In		In	In				
SEND BROADCAST DATAGRAM	22h/A2h	Out		In	In	In				
SEND DATAGRAM	20h/A0h	Out		In	In	In	In			

* LISTEN can use a CallName of "*" to match any name field of any CALL.
**RECEIVE DATAGRAM can set the Ncb_Num field to 0xFF to match any register local name.

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a session partner. This function is entered with a local session number in **Ncb_Lsn** and a buffer specification. Note that the maximum buffer length is 65,535. On exit, SEND returns values in **Ncb_RetCode** and **Ncb_Cmd_Cplt.** Sessions guarantee data integrity and order: if a SEND does not complete correctly, the session aborts.

SEND BROADCAST DATAGRAM transmits a message to every network host. Every process with a pending **receive broadcast** function receives the message.

SEND DATAGRAM transmits a message to the network. A process receives the message if it has a pending RECEIVE DATAGRAM having an **Ncb_Num** field that matches the **Ncb_CallName** of the sender. Only one process per system can receive the datagram. SEND DATAGRAM requires a buffer specification, a local name number in **Ncb_Num,** and a remote name in **Ncb_CallName.**

SENDING DATAGRAMS

DATAGRAM.ASM (Listing 3) is a simple program to send datagrams. It uses the first command-line argument for the remote name. If the argument is "*," it sends a broadcast datagram; the remainder of the command line forms the datagram message. This is as simple as a NetBIOS program can get.

The program follows six steps:

- Check for a NetBIOS driver.
- Register name in local name table.
- Parse the command line.
- Build either a normal or a broadcast datagram NCB.
- Send the datagram.
- Delete its name from the name table.

SPY VS. SPY

SPY.ASM (Listing 4) is a program to receive broadcast datagrams and datagrams sent to "Spy." It displays the message contents in both hex and ASCII. The program is supposed to display all NetBIOS datagrams, but NetBIOS ignores datagrams sent to unregistered names.

The main loop in SPY.ASM issues two NetBIOS functions: a **receive** datagram and a **receive broadcast** datagram. Both functions set the no-wait option, so NetBIOS immediately returns control to the program. The program polls each NCB and the keyboard for activity. When a datagram arrives, SPY dumps it to the console and issues another **receive** function.

If two broadcast datagrams occur in rapid succession, SPY can miss the second datagram. This trade-off keeps the program simple.

Pressing a key cancels the pending **receive** functions and deletes the local name. The program then exits. Do not press Control-C to abort the program during a display operation. Aborting the program would leave an active NCB, and the system would probably crash. If you accidentally press Control-C, reset the computer.

USING SESSIONS

SERVER.ASM (Listing 5) is a simple network file server. It issues a no-wait LISTEN function and waits for network or keyboard activity. If a client opens a session, the server issues a **receive.** It expects four data objects: a file position, a maximum byte count, a direction flag, and a file name.

Assuming that the 1-byte direction flag is "r" for read, the server opens the file for input and sets the position pointer. Next, the server reads the file and sends the data to the client. The server transfers data until it reaches the end of the file or the maximum byte count. After sending the last buffer, the server closes the session with a **hang up** function and issues another LISTEN for the next client. If a keystroke occurs, the server cancels the listen, deletes its local name, and exits.

CLIENT.ASM (available on the code disk and over *PJ* bulletin boards) is a simple file transfer program. After registering its local name, it issues a CALL to a file server. When the session opens, it sends a file position, length, direction flag, and file name. Using a file position of 0 and a length of –1 ensures that the file server will transfer the entire file.

The client opens a local output file and enters a loop. The loop reads from the network and writes to the output file until the **read** function returns a code indicating that the session closed. Then the client closes the output file, deletes its local NetBIOS name, and returns to DOS.

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NETWORK WITH CARE

Because many more errors are possible in a network environment, error handling and recovery can be complicated. All four sample programs suffer from weak error processing. The goal of the programs is to demonstrate a basic network interface, not to cover every detail of the NetBIOS communications interface.

Using the terminator feature of the start-up code could ensure that the program cleans up, no matter how it terminates. For more information, see "Real-mode virtual memory" (*PJ* 9.1).

Tying the basic network functions into the error system would permit more generic error handling. It would also eliminate the error text from the sample programs. "Errors and stream I/O" (*PJ* 8.4) provides more information on error handling.

MORE INFORMATION

A good resource on NetBIOS programming is the *C Programmer's Guide to NetBIOS*, by W. David Schwaderer (Howard W. Sams, 1988). Obviously intended for C hackers, the book also contains useful information for assembly language programmers. It also includes a wonderful reference card. Many of the symbols in the sample code come from this book. Also see the article "Exploiting NetBIOS," written by Schwaderer (*PJ* 8.1).

If you lack a network, the quick and easy way to experiment with NetBIOS programming is to purchase a Lantastic starter kit. The 2-megabit version is the least expensive, but the smart move is to get Western Digital Ethernet cards and run the Lantastic network operating system on top of them. If you spend some big bucks on a Novell network, you won't need new network cards. If you already have a Novell network, NetWare comes with a NetBIOS emulator. The Novell NetBIOS TSR must be invoked on your workstation after the NetWare shell is in place (IPX and NETx).

Next time, I will organize the code from past articles. I'm tired of clipping and snipping code from my library for the code disks. In future articles, each code disk will include the entire library. I will also take a look at the new version of Microsoft MASM 6.0. PJ

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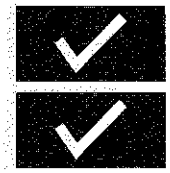

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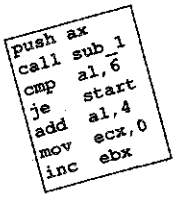

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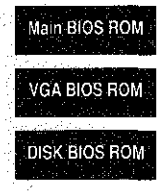

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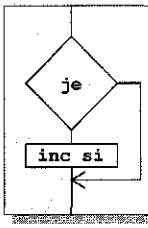

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```
ertx_send               db  'SEND error',0
ertx_listen             db  'LISTEN error',0
ertx_receive            db  'RECEIVE error',0
ertx_read_only          db  'Server only supports read requests',0
ertx_file_not_found     db  'File not found',0
ertx_read               db  'File read error',0

exiting_text            db  'Exiting',0
low_iq_server_text      db  'Low IQ Server',0
logo_text               db  'Simple NetBIOS File Server',13,10
                        db  'Press ESC to exit',0

        .data?

listen_ncb      ncb <>

;
; the order of these four objects is important
position_req    dd  ?                   ; file position requested for
                                           transfer
length_req      dd  ?                   ; length of transfer request
direction_flag  db  ?                   ; 'r' for receive, 's' for send
filename_req    db FILENAME_MAX dup(?)  ; requested file and path
                db  ?                   ; (ensure path is asciiz)

add_name db  ?
session_number  db  ?
file_buffer     db  512 dup(?)

        .code
        extn  startup,netbios_check,netbios_add_name,clear_ncb,strcpy
        extn  netbios_receive_wait,get_input_state,puts,netbios_hang_up
        extn  exit_program,netbios_delete_name,netbios_cancel,close_file
        extn  netbios_send_wait,read_from_file,select_min_count,
              netbios_call
        extn  move_file_pointer,open_input_file

;;      main
;
main    proc
        assume  ds:DGROUP               ; (test program is small model)

        lea     si,logo_text
        call    puts

        call    netbios_check
        jc      mai3                    ;  if no netbios driver
        lea     si,low_iq_server_text   ; *Low IQ Server*
        call    netbios_add_name
        jc      mai5                    ;  if add name failed
        mov     add_name,al

mai1:   lea     si,listen_ncb           ; build listen control block
        call    clear_ncb

        mov     Ncb_Command[si],NB_LISTEN
        mov     Ncb_CallName[si],'*'    ;  (accept CALLs from anyone)

        lea     si,low_iq_server_text   ;  enter server name
        lea     di,listen_ncb.Ncb_Name
        call    strcpy

        lea     si,listen_ncb
        mov     Ncb_Rto[si],-1 ;4*2     ;  receive  timeout is 4 seconds
        mov     Ncb_Sto[si],-1 ;30*2    ;  transmit timeout is 30 seconds
        call    netbios_call            ; begin listening for client
        jc      mai6                    ;  if error posting listen command

mai2:   call    get_input_state
        jnz     mai7                    ;  if keyboard exit request
        mov     al,Ncb_Cmd_Cplt[si]
        cmp     al,0FFh
        je      mai2                    ;  if listen still pending
        cmp     al,0
        jne     mai6                    ;  if listen failed

        mov     al,Ncb_Lsn[si]          ; save session number
        mov     session_number,al

        lea     di,position_req         ; get transfer request from client
        mov     cx,size position_req+size length_req+1+size filename_req
        call    netbios_receive_wait    ;  (AL is session)
        jc      mai10                   ;  if unexpected error

        cmp     direction_flag,'r'      ; check request code
        jne     mai12                   ;  if not read file

        call    process_read_request    ;  else transfer file to client
        jnc     mai1                    ;  if no errors, continue

mai3:   lea     si,ertx_driver          ; *No NetBIOS driver*
mai4:   call    puts
        jmp     exit_program

mai5:   lea     si,ertx_add_name        ; *ADD NAME error*
        jmp     mai4

mai6:   lea     si,ertx_listen          ; *LISTEN error*
        jmp     mai8

mai7:   lea     si,listen_ncb
        call    netbios_cancel
        lea     si,exiting_text         ; *Exiting*

mai8:   call    puts
mai9:   lea     si,low_iq_server_text
        call    netbios_delete_name
        jmp     exit_program

mai10:  lea     si,ertx_receive         ; *RECEIVE error*
mai11:  call    puts
        mov     al,session_number
        call    netbios_hang_up
        jmp     mai9

mai12:  lea     si,ertx_read_only    ; *Server only supports read requests*
        jmp     mai11
main    endp

;;      process read request
;
;       entry   DS      DGROUP
;       uses    AX,BX,CX,DX,SI,DI
process_read_request proc
        assume  ds:DGROUP               ; (test program is small model)

        lea     si,filename_req         ; open requested file
        call    open_input_file
        jc      prr2                    ;  if file not found

        mov     ax,wptr position_req    ; set file position
        mov     dx,wptr position_req+2
        call    move_file_pointer

prr1:   mov     cx,size file_buffer     ; choose transfer size
        mov     ax,wptr length_req
        mov     dx,wptr length_req+2
        call    select_min_count
        jcxz    prr5                    ;  if length limit reached

        lea     di,file_buffer          ; read file data
        call    read_from_file
        jc      prr3                    ;  if file read error
        mov     cx,ax
        jcxz    prr5                    ;  if end of file

        sub     wptr length_req,cx      ; update transfer limit
        sbb     wptr length_req+2,ZERO

        mov     al,session_number       ; send file data to client
        call    netbios_send_wait       ;  (ES:DI->file_buffer)
        jnc     prr1                    ;  if OK, continue transfer

        lea     si,ertx_send            ; *SEND error*
        jmp     prr4

prr2:   lea     si,ertx_file_not_found  ; *File not found*
        jmp     prr4

prr3:   lea     si,ertx_read            ; *File read error*
prr4:   call    puts
        stc
        ret
prr5:   call    close_file              ; close file and hang up session at
        mov     al,session_number       ;   end of file or when requested
        call    netbios_hang_up         ;   transfer count
        ret
process_read_request endp

        end
```


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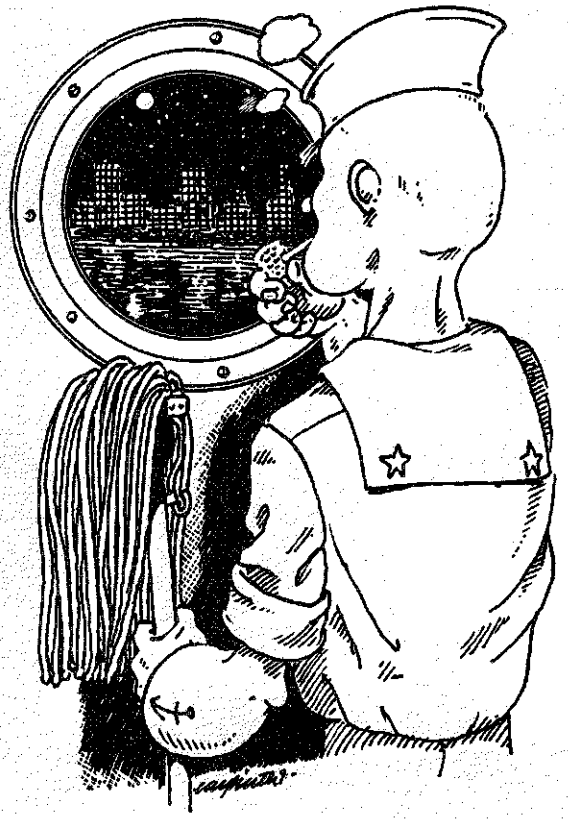
Window viewports

Part 2: Adding a display layer to our text windowing system



By Allen Holub

In my last article, "Text buffers in Windows" (*PJ* 9.1), I presented the text-manipulation part of a reasonably sophisticated window-management system that compiles under Borland C++ (formerly Turbo C++), using only the C compiler. Although the code is being tested with the 2.0 release of the compiler, it should port to other compilers with little difficulty.

PAUSE FOR MEMORY REFRESH

The windowing system described in these articles supports various video adapters, allowing 43- and 50-line screens on the EGA and VGA. It supports line wrap and scrolling in windows, boxed windows, etc., as well as basic editing features such as inserting and deleting characters and lines. The most important feature, however, is that the underlying text buffer (which I'll call the "window") can be much larger than the aperture into the text buffer that's displayed on the screen (the "viewport"). The text buffer can be made to slide horizontally or vertically beneath the viewport.

This feature is particularly useful in data-entry screens, which are, after all, what windows are all about. For example, you can have a 40-column-wide field in a data-entry screen that is actually a viewport into a 128-column window. When your typed text exceeds the 40 columns on the screen, it slides under the viewport as you add characters until the window's full width has been reached. The effect is similar to the horizontal-scrolling feature of most editors. You can also access multiple-line windows through a single-line viewport, using the cursor to bring hidden lines into view.

A SCREEN WITH A VIEW

This article presents the viewport component of the system—the code that draws the window on the screen. You can use these functions as a stand-alone—but primitive—window system.

The system starts with some macro definitions in VIEWPORT.H (Listing 1). The **#ifdef NEAR_HEAP** takes care of image management. As the viewport works, it needs to save two potentially large images: first, the underlying text must be saved when the viewport is created so that it can be restored when the viewport is deleted or moved. Next, the viewport needs to save a snapshot of itself when it is deactivated. This makes it possible to deactivate a window and then overwrite all or part of it with a second window. By deactivating this second window and reactivating the first, you can bring the first window back to the foreground without deleting the second. The reactivation subroutine uses the snapshot to redraw the window.

Having several windows on a VGA screen can use up quite a bit of memory. If **NEAR_HEAP** is defined, these images are saved in the standard, small-model heap. If **NEAR_HEAP** isn't defined, memory for the saved images is allocated from outside the program's data segment. This latter option lets you write a program in the small model, even if it uses several hundred kilobytes for window images. A similar mechanism (described in the previous article) holds the text buffers, which can also be quite large.

EDIFICE COMPLEX

The **viewport** structure is declared in Listing 1. The **magic** field is used to identify a valid, initialized **viewport** structure. It's set to **V_MAGIC** (defined just above the structure definition) when you initialize the **viewport**, and to **~V_MAGIC** when the **viewport** is discarded. All viewport functions and macros check this field before they manipulate the structure.

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ILLUSTRATION BY JIM CARPENTER

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The next two bit fields indicate whether the **viewport** is closed or inactive. A **closed** viewport has been removed from the screen, and its contents must be redrawn by the application program if it is reopened. A viewport must be closed in order to be resized. An **inactive** viewport has merely been deactivated, not closed. A subsequent reopen will restore it to its predeactivated condition. A deactivated **viewport** can be hidden (removed from the screen) while it is deactivated. Whether the viewport was hidden or visible at deactivation time, the **old_image** pointer at the bottom of the structure will be non-**NULL** and will hold a snapshot of the viewport.

The next two bit fields control how viewports are initialized. If **clearok** is set, the window is cleared when it is first opened (but not when it is reactivated). If **saveok** is set, the underlying text is saved (in a buffer pointed to by the **savebuf** field) when the viewport is first opened, and restored when the viewport is either closed or hidden.

Setting **saveok** to false will save some memory by not saving the text, but such a viewport cannot be moved without messing up the screen; an image of the viewport will remain on screen even after it is closed. These sorts of windows are useful, nonetheless, for subwindows, such as a field within a data-entry screen. The parent window is created first (and the underlying text is saved by it); then the subwindows are created on top of the parent without saving. The other fields in the **viewport** structure are self-explanatory.

MACRO MANIA

Listing 1 then continues with a host of macros that are used to manipulate the viewport. All are passed a **viewport** pointer as the first argument. The macro

```
v_valid(viewport v)
```

evaluates true if the argument points at a valid viewport (if its **magic** field holds a valid number).

A viewport is initialized to various defaults, which can be changed before it is displayed. The two macros

```
v_foreground(viewport v, int color)
v_background(viewport v, int color)
```

and the **v_saveok** and **v_clearok** macros discussed below typically are used after the **viewport** is initialized—but before it is displayed for the first time—in order to change the default settings. The current macros change the foreground and the background colors, respectively. The default colors are bright white characters on a black background. Other colors are defined in Borland's CONIO.H file, with symbolic names for the standard IBM character attributes. The new colors take effect immediately—any characters written to the viewport will have the new attributes. Existing characters are not redrawn, however: they remain in the original color unless they are overwritten. These macros do not test for a valid **viewport**-pointer argument.

A newly created window is not displayed until it is explicitly opened. A default window does not save text under the window when it is opened,

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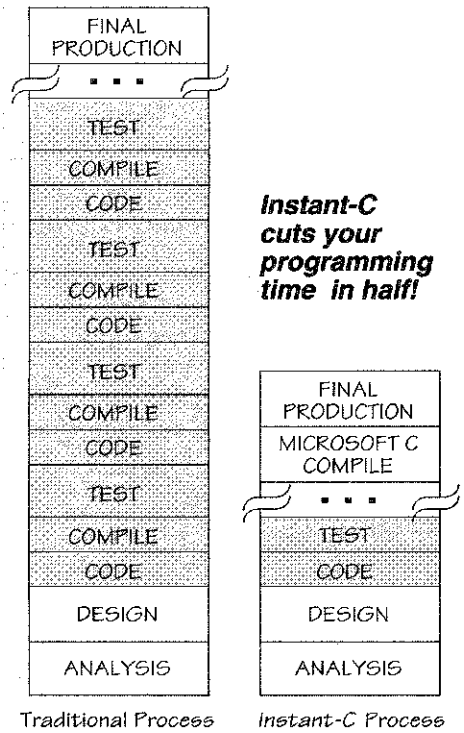

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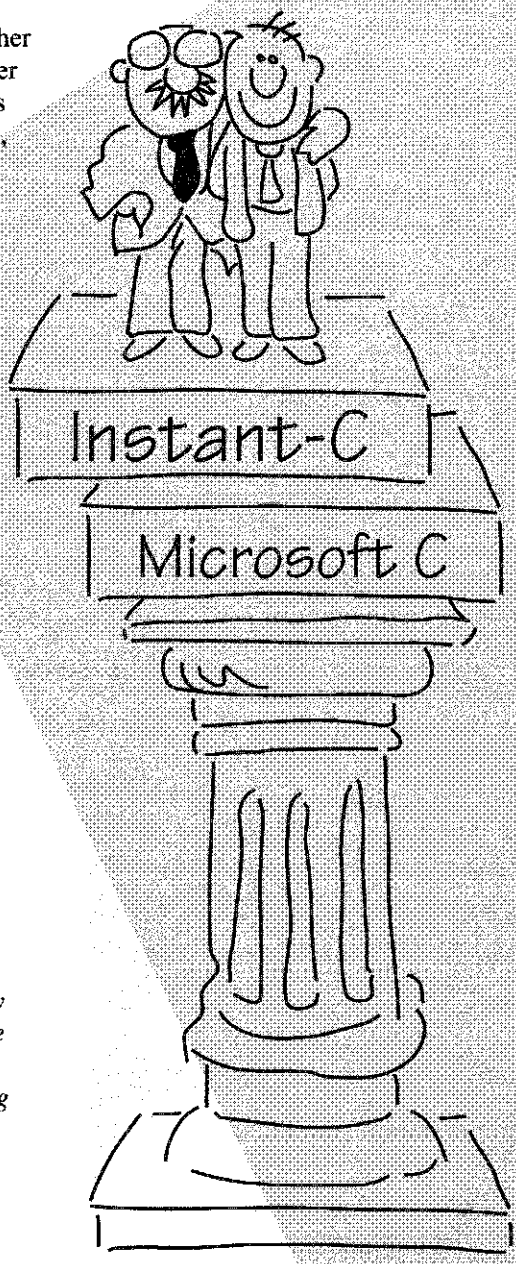

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LISTING 1

```
/* viewport.h- viewport Definition and Macros */
#ifndef __VIEWPORT_H
#define __VIEWPORT_H

#include <alloc.h>              /* needed for farmalloc prototype */

#ifdef NEAR_HEAP
#       define VMALLOC  malloc /* Allocate memory for buffer.          */
#       define VFREE    free   /* Free memory used for buffer.         */
        typedef char    *cptr; /* pointer to a character buffer        */
        typedef int     *iptr; /* pointer to an int buffer             */
#else
#       define VMALLOC   farmalloc
#       define VFREE     farfree
        typedef char far* cptr;
        typedef int  far* iptr;
#endif

#define VMAXCOLS        80      /* Max. columns in a viewport           */
#define VMAXLINES       50      /* Max. lines (rows) in a viewport      */
#define VMAGIC          0xcdef  /* Magic number used to recognize a     */
                                /* valid viewport.                      */
#define VINIT_CHAR      ' '     /* clearok and v_scroll_region init.    */
                                /* viewport w/ this character           */
typedef struct viewport
{
    unsigned magic;         /* Magic number--identifies a valid viewport */

    unsigned inactive: 1 ; /* viewport is deactivated but still open    */
    unsigned closed  : 1 ; /* viewport is closed and deactivated.       */
    unsigned clearok : 1 ; /* Clear (blank fill) viewport on 1st open.  */
    unsigned saveok  : 1 ; /* Save area under viewport before displaying*/

    unsigned char nrows  ; /* number of rows in viewport                */
    unsigned char ncols  ; /* number of columns in viewport             */

    unsigned char row;      /* absolute coordinate of upper-left corner  */
    unsigned char col;
    unsigned char cur_row; /* cursor position     */
    unsigned char cur_col;

    unsigned char fcolor;  /* foreground color    */
    unsigned char bcolor;  /* background color    */
    iptr savebuf;          /* underlying text when window first opened  */
    iptr old_image;        /* old image when window closed or deactivated*/
}
viewport;
 /*-------------------------------------------------------------------------*/
#define v_valid(      v       ) ((v)->magic == VMAGIC)
#define v_foreground( v, color) ((v)->fcolor =  (color) )
#define v_background( v, color) ((v)->bcolor =  (color) )
#define v_saveok(     v, on   ) ((v)->saveok =  (on)!=0 )
#define v_clearok(    v, on   ) ((v)->clearok=  (on)!=0 )
#define v_getposn( rp, cp     ) ((*(rp)=(v)->row),  (*(cp)=(v)->col) )
#define v_row(      v ) (v_valid(v)? ( (v)->cur_row              ):-1)
#define v_col(      v ) (v_valid(v)? ( (v)->cur_col              ):-1)
#define v_nrows(    v ) (v_valid(v)? ( (v)->nrows                ): 0)
#define v_ncols(    v ) (v_valid(v)? ( (v)- >ncol         ): 0)
#define v_ateol(    v ) (v_valid(v)? ( (v)->cur_col== (v)- >ncols-1 ): 0)
#define v_atbol(    v ) (v_valid(v)? ( (v)->cur_col== 0          ): 0)
#define v_ateob(    v ) (v_valid(v)? ( (v)->cur_row== (v)- >nrows-1 ): 0)
#define v_advance( v ) v_gotorc( (v), (v)->cur_row, (v)- >cur_col + 1  )
#define v_backup(  v ) v_gotorc( (v), (v)->cur_row, (v)- >cur_col - 1  )
#define v_cr(      v ) v_gotorc( (v), (v)->cur_row     , 0            )
#define v_up(      v ) v_gotorc( (v), (v)->cur_row - 1, (v)->cur_col  )
#define v_down(    v ) v_gotorc( (v), (v)->cur_row + 1, (v)->cur_col  )

#define v_scroll(v,u,l) v_scroll_region(v,u,l,0,0,VMAXCOLS,VMAXLINES)
#define v_move_rel(v, dr, dc) v_move((v), (v)->row-(dr), (v)->col-(dc))
/*-------------------------------------------------------------------------*/
int  v_startup    ( int mode    );
void v_shutdown   ( void        );
int  v_construct  ( viewport *v );
int  v_destroy    ( viewport *v );
int  v_open       ( viewport *v );
int  v_close      ( viewport *v );
int  v_deactivate ( viewport *v, int hide );
int  v_size       ( viewport *v, unsigned nrows, unsigned ncols );
int  v_move       ( viewport *v, unsigned row,   unsigned col   );
int  v_gotorc     ( viewport *v, unsigned row,   unsigned col   );
int  v_putc       ( viewport *v, int c, int move_cur );
int  v_puts       ( viewport *v, char *s );
int  v_getc       ( viewport *v );
int  v_gets       ( viewport *v, int n,  char *s  );
int  v_scroll_region( viewport *v, int up, int to_left, int left, int top,
                                   int right, int bottom );
int  v_clear      ( viewport *v );
int  v_cleartoeol ( viewport *v );

/* Workhorse functions, not intended to be user callable*/

void _v_save_scr    (iptr image, int row, int col, int nrows, int ncols);
void _v_restore_scr (iptr image, int row, int col, int nrows, int ncols);
void _v_fill_scr    (int c_att,  int row, int col, int nrows, int ncols);
#endif /* #ifdef __VIEWPORT_H */
```

LISTING 2

```
/* Functions to start up and shut down the Video System,
   construct and destroy viewports */
#include <stdio.h>
#include <stdlib.h>
#include <conio.h>
#include <tools/viewport.h>

static int Old_mode = LASTMODE; /* startup video mode, Return to this
                                 * mode when the window system exits.
                                 */
static unsigned Times_called = 0;

void v_shutdown ( void )
{
    /* V_shutdown shuts down the video system sometime before the
     * normal shutdown at program termination.
     */
    if( Old_mode != LASTMODE ){
        textmode( Old_mode );   /* Restore original mode */
        Old_mode = LASTMODE;
    }
    Times_called = 0;           /* allow a restart */
}

int v_startup( int mode )
{
    /* v_startup is passed either a video mode or LASTMODE, as defined in
     * <conio.h>, if mode==LASTMODE, the current video mode is used.
     *
     * v_startup calls atexit(), so the video system will shut down
     * automatically when the program exits. The video system can
     * be initialized only once. Subsequent calls do nothing & return
     * false unless the video system is shut down explicitly with a
     * v_shutdown() call.
     */
    struct text_info info;

    if( Times_called++ == 0){
        gettextinfo( &info );
        Old_mode = info.currmode;
        if( mode != LASTMODE )
            textmode( mode );
        atexit( v_shutdown );   /* Call v_shutdown on exit */
    }
    return( Times_called == 1 );
}
int v_construct( viewport *v )
{
    /* Initialize a previously allocated (with malloc() or a declaration)
     * viewport, setting various fields to reasonable defaults. It's an
     * error to construct a viewport more than once without an intervening
     * v_destroy call.
     */
    struct text_info info;
    gettextinfo( &info );

    if( v->magic == VMAGIC )
        return 0;

    v->magic     = VMAGIC;
    v->inactive  = 1;
    v->closed    = 1;
    v->clearok   = 0;
    v->saveok    = 0;
    v->nrows     = info.screenheight;   /* Initial size is entire screen */
    v->ncols     = info.screenwidth;
    v->row       = 0;                   /* Upper-left corner */
    v->col       = 0;
    v->cur_col   = 0;
    v->cur_row   = 0;
    v->fcolor    = BLACK ;
    v->bcolor    = LIGHTGRAY ;
    v->savebuf   = NULL;
    v->old_image = NULL;
    return 1;
}

int v_destroy ( viewport *v )
{
    /* Destroy the viewport, freeing all internally allocated memory, but
     * do not free the viewport itself.
```

continued

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```
    */

    if( v->magic != VMAGIC ){ return 0;  }
    if( !v->closed         ){ v_close( v );  }
    v->magic = ~VMAGIC;      /* guaranteed not to be the same as VMAGIC */
    return 1;
}
    /* Workhorse functions: Save, Restore, and Fill Screen Regions */
void _v_save_scr( iptr image, int row, int col, int nrows, int ncols )
{
    /* Copy the indicated region of the screen into image. */
    int i;
    int buf[ VMAXCOLS ], *bp;
    while( --nrows >= 0 ){
        gettext( col+1, row+1, col+ncols, row+1, buf );
        ++row;
        bp = buf;
        for( i = ncols ; --i >= 0 ; )
            *image++ = *bp++;
    }
}
void _v_restore_scr( iptr image, int row, int col, int nrows, int ncols )
{
    /* Like save_scr, but goes in the other direction */

    int i;
    int buf[ VMAXCOLS ], *bp;
    while( --nrows >= 0 ){
        bp = buf;
        for( i = ncols ; --i >= 0 ; )
            *bp++ = *image++ ;
        puttext( col+1, row+1, col+ncols, row+1, buf );
        ++row;
    }
}
void _v_fill_scr( int c_att, int row, int col, int nrows, int ncols )
{
    /* Fill the indicated region of the screen with c_att, which is
     * a character/attribute pair. row and col start at (0,0)
     */
    int i;
    int buf[ VMAXCOLS ], *bp;
    bp = buf;
        for( i = ncols ; --i >= 0 ; )
            *bp++ = c_att;
    for(; --nrows >= 0 ; ++row )
        puttext( col+1, row+1, col+ncols, row+1, buf );
}
int v_clear( viewport *v )
{
    _v_fill_scr( VINIT_CHAR | (v->bcolor << 4 | v- >fcolor) << 8,
                                        v->row, v->col, v->nrows, v->ncols );
    return 1;
}
int v_cleartoeol( viewport *v )
{
    _v_fill_scr( VINIT_CHAR | (v->bcolor << 4 | v- >fcolor) << 8,
        v->row + v_cur_row, v->col + v_cur_col, 1, v->ncols - v->cur_col );
    return 1;
}
```

LISTING 3

```
#include <stdio.h>
```

continued

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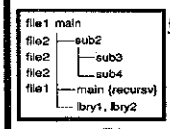

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```
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     CALLS: sub3 sub4
     PARAM: arg1 arg2
     LOCAL: var1
     GLOBL: var2 var3
*********************F*/
```

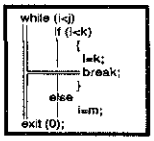

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nor does it clear the window (overwrite it with blanks) when it is opened. The two macros

```
v_saveok ( viewport v, int on )
v_clearok( viewport v, int on )
```

are used to change this behavior. Pass in a **true** second argument to enable the feature, a **false** to disable it. These macros do not test for a valid **viewport**-pointer argument.

MACROS ON THE MOVE

Some macros are used for positioning.

```
v_getposn( int *rp, int *cp )
```

tells you where the viewport is located on the screen. It loads ***rp** and ***cp** with the current row and column coordinates of the window's upper-left corner. The screen's upper-left corner is at (0,0).

To return the current viewport-relative cursor position, use

```
v_row(viewport *v)
v_col(viewport *v)
```

The upper-left corner of the viewport is (0,0). Both macros evaluate to –1 if **v** doesn't point at a valid **viewport**.

The following three macros

```
v_ateol(viewport *v)
v_ateob(viewport *v)
v_atbol(viewport *v)
```

evaluate true if the cursor is at the end of the line (touching the right edge of the viewport), at the end of the buffer (on the last line of the viewport), or at the beginning of the line (touching the left edge of the viewport). They all evaluate false if **v** doesn't point at a valid **viewport**.

The next group of macros enable cursor or window movement.

```
v_advance(viewport *v)
v_backup (viewport *v)
v_up     (viewport *v)
v_down   (viewport *v)
v_cr     (viewport *v)
```

The first four move the cursor one position to the right, left, up, and down, respectively; **v_cr** moves it to the left edge of the current line. The macros don't allow the cursor to go past the edge of the viewport. All evaluate true if the move is successful, or false if the move would cause the cursor to move outside the viewport.

```
v_move_rel(viewport *v, int dr, int dc)
```

moves the entire viewport some distance relative to the current position. **dr** ("delta row") is the distance along the vertical axis; **dc** ("delta column") is the distance along the horizontal. A negative **dr** goes down, a negative **dc** goes right. This rather counterintuitive setup lets the arguments match the **v_scroll** function (see below), which scrolls the text region within the viewport. That is, if you call **v_scroll** with the same second and third arguments as a **v_move_rel** invocation, the text moves within the viewport by the same amount and direction that **v_move_rel** moves the viewport as a whole.

STARTUP AND SHUTDOWN

The rest of Listing 1 contains prototypes for other library functions. On the code disk and over *PJ*'s BBS services, the functions are in separate files. However, to save space here (and to avoid printing **#include <stdio.h>** 20 times), the viewport functions have been merged into Listings 2–4.

The first two functions in Listing 2 start up and shut down the entire viewport system. The first is

```
int v_startup( int mode )
```

v_startup is passed either a video mode or LASTMODE (all defined in CONIO.H). If **mode** is LASTMODE, the current video mode is used; otherwise, the system flips into the new video mode. Available modes are

```
BW40, C40, BW80, C80, MONO, C4350
```

The names are self-explanatory, except for C4350, which gives you 43-line text mode on an EGA and 50-line text mode on a VGA. Usually, the video system is initialized only once. The first call to **v_startup** returns true. Subsequent calls do nothing and return false.

The video system shuts down automatically (and the old video mode is

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```
#include <stdlib.h>
#include <conio.h>
#include <tools/viewport.h>

int v_open( viewport *v )
{       /*  Open (save underlying text and clear underlying region) the
            viewport.
     *  If clearok is enabled, area under viewport is filled with blanks
     *  the first time the viewport is opened, the behavior of subsequent
     *  calls depends on whether the viewport was closed or deactivated.
     *  If closed and clearok is enabled, the area is filled with blanks.
     *  If deactivated, the area is filled with the previous contents
     *  (at deactivate time). Underlying is saved if saveok is enabled
     *  and this is (1) a new or closed viewport or (2) a deactivated,
     *  hidden viewport. The text isn't saved for deactivated, but visible
     *  viewports. All the viewport-manipulation functions will open
     *  the window implicitly if an explicit open hasn't been performed.
     */
    if( v->magic != VMAGIC )
        return 0;

    /* If the window is closed, then it doesn't exist on the screen. Save
     * the underlying text and initialize if required. If it's inactive
     * but not closed, then it still exists on the screen and a refresh
     * is required.
     */
    if( v->closed || v->inactive ){
        if( v->saveok && !v->savebuf ){
            if( !(v->savebuf = VMALLOC(v->nrows * v- >ncols * sizeof(int))))
                return 0;
            _v_save_scr( v->savebuf, v->row, v->col, v- >nrows, v->ncols );
        }

        /* Initialize the viewport, either to the original image (before
         * it was deactivated) or to blanks (if clearok is true). If neither
         * condition is true, don't initialize. (I'm assuming that the
         * application will then fill up the window.)
         */

        if( v->inactive && v->old_image ){
            _v_restore_scr( v->old_image, v->row, v- >col, v->nrows,
                                                           v->ncols );
            VFREE( v->old_image );
            v->old_image = NULL;
        }
        else if( v->clearok )
            v_clear( v );
    }

    v->closed   = 0;
    v->inactive = 0;
    v_gotorc( v, v->cur_row, v->cur_col );
    return 1;
}
int v_close( viewport *v )
{
    /* Close the viewport (set it back to a pristine condition). The
     * underlying text is restored if it was saved by v_open. Any
     * old image (as is saved by v_deactivate()) is discarded.
     */

    if( v->magic != VMAGIC )
        return 0;

    if( v->old_image )                  /* If window is inactive,       */
        VFREE( v->old_image );          /* free the old image           */

    if( v->savebuf ){                    /* and restore original text.   */
        _v_restore_scr( v->savebuf, v->row, v->col, v- >nrows, v->ncols );
        VFREE( v->savebuf );
        v->savebuf = NULL;
    }
    v->closed   = 1;
    v->inactive = 1;
    return 1;
}

int v_deactivate( viewport *v, int hide )
{
    /* V_close() effectively sets the viewport back to its original,
     * pristine condition, as if it had never been opened. v_deactivate()
     * is less thorough. The contents of the window are saved in a local
     * buffer, and if hide is true, the original underlying text is
     * restored. A subsequent vopen() call restores the window to the
     * condition it was in before the vdeactivate.
     */

    if( v->magic != VMAGIC  ||  v->inactive )
        return 0;

    v->inactive = 1;

    if( !v->old_image )
        if( !(v->old_image = VMALLOC(v->nrows*v- >ncols*sizeof(int))))
            return 0;
    _v_save_scr( v->old_image, v->row, v->col, v- >nrows, v->ncols );

    if( hide && v->savebuf ){    /* Restore original text. */
        _v_restore_scr( v->savebuf, v->row, v->col, v- >nrows, v->ncols );
        VFREE( v->savebuf );
        v->savebuf = NULL;       /* Set savebuf null to tell v_open to */
    }                            /* save underlying text on reopen.    */
    return 1;
}

int v_size( viewport *v, unsigned nrows, unsigned ncols )
{
    /* Change the viewport size. The viewport must be closed
     * (not just deactivated) to change its size. False is
     * returned and nothing happens if the viewport isn't
     * closed, true otherwise.
     */
    if( v->magic != VMAGIC  ||  !v->closed )
        return 0;

    if( v->savebuf ){            /* A differently sized save buffer is   */
                                 /* required for the new size. Will      */
        VFREE( v->savebuf );     /* be allocated by v_open.              */
        v->savebuf = NULL;
    }
    if( v->old_image ){
        VFREE( v->old_image );
        v->old_image = NULL;
    }
    v->nrows = nrows;            /* Set up the new size. */
    v->ncols = ncols;

    return 1;
}

int v_move( viewport *v, unsigned row, unsigned col )
{
    /* Move the viewport to indicated absolute row and column. The
     * viewport must be closed or hidden to move it. If the viewport
     * is open and active, it's deactivated, moved, then reopened.
     * You may not move the viewport past the edge of the screen.
     * Return true if the viewport ended up where specified, false if
     * it bumped up against the side of the screen.
     */

    int rval       = 1 ;   /* return value */
    int was_active = !v->inactive;
    struct text_info info;

    if( v->magic != VMAGIC )
        return 0;

    gettextinfo( &info );

    if( row+v->nrows > info.screenheight  ){    /* Truncate row and col */
                                                /* so that the viewport */
        row = info.screenheight - v->nrows ;    /* stays on the screen. */
        rval = 0;
    }
    if( col+v->ncols > info.screenwidth ){
        col = info.screenwidth - v->ncols ;
        rval = 0;
    }
    if( was_active )
        v_deactivate( v, 1 );

    v->row = row;
    v->col = col;
    if( was_active )
        v_open( v );
    return rval;
}
```

LISTING 4

```
#include <stdio.h>
#include <stdlib.h>
#include <conio.h>
#include <tools/viewport.h>
int v_gotorc( viewport *v, unsigned row, unsigned col )
{
    /* Move the cursor to the indicated viewport-relative row
     * and column. The cursor is not allowed to go past the edge
     * of the viewport. Nonetheless, it will go as far as possible
     * in the required direction. Return true if the cursor ended
     * up where specified, false if it didn't because it bumped
     * up against the side of the viewport.
     */
```

continued

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restored) when the program terminates. A second function,

```
void v_shutdown ( void )
```

shuts down the video system before the normal shutdown at program termination. If needed, the video system can be restarted by a subsequent **v_startup**, but Borland's mode-change subroutine clears the screen as part of the start-up process.

CONSTRUCT AND DESTROY

A **viewport** structure is allocated using either a declaration or a **malloc** call. The structure is initialized (though not displayed) by a call to

```
int v_construct( viewport *v )
```

When the structure is displayed, it occupies the entire screen; the cursor is in the upper-left corner. Characters are white on black by default. You can change the defaults after the construction and before the open (which does the display) by using functions and macros such as the **foreground** and **background** macros discussed above.

The complementary subroutine

```
int v_destroy ( viewport *v )
```

removes the viewport from the screen (if it hasn't already been removed) and then frees all the internally allocated memory used for the viewport. It does not free the memory pointed to by the **v** argument, however (in case **v** points to a local variable rather than to **malloc**ed memory). **v_destroy** must be called before a local **viewport** goes out of scope.

SNAPSHOT ARRAYS

The remainder of Listing 2 contains the workhorse functions that save and restore snapshots of rectangular regions and fill a region with a character value. Although Borland's **gettext** and **puttext** functions provide these snapshots, they can't be used in a simple way, because the target buffer might be in far memory (if **NEAR_HEAP** was not defined when the modules were compiled). The solution is to use **gettext** or **puttext** to read from or write to a small buffer that holds a single line from the viewport. A small loop then copies this line-buffer's contents to or from the target buffer. Note that the snapshot arrays are arrays of **int**—not of **char**—because a screen character is a 16-bit quantity; the ASCII value is in the low byte, and a color-specification attribute is in the high byte.

The final function in Listing 2

```
int v_clear( viewport *v )
```

clears the viewport (fills it with blanks).

VIEWPORT HIDE AND SEEK

Listing 3 contains the bulk of the other viewport functions. The

```
int v_open( viewport *v )
```

function displays the viewport on the screen. The **v_open** function is passed a pointer to an initialized **viewport**, which might have been modified by invocations of macros such as **saveok** or **foreground.** You can also call this function to reactivate a deactivated window. All the window I/O and cursor-positioning routines and macros call **v_open** implicitly, so an explicit **v_open** call is required only to display a window or bring it to the foreground without modifying it.

If **clearok** is enabled, the area under the viewport is filled with blanks the first time the viewport is opened. The behavior of subsequent **v_open** calls depends on whether the viewport was closed or was deactivated. If it was closed and if **clearok** is enabled (by invoking the **clearok** macro on the current viewport), the area is filled with blanks on reopening. If the viewport was deactivated, the area is filled with the previous contents (as stored at deactivate time).

The underlying text is saved before the region is overwritten, but only if **saveok** is enabled and if one of the following applies: this is a new or previously closed viewport, or this is both a deactivated and hidden viewport. The underlying text is not saved for deactivated (but visible) viewports;

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rather, the save buffer from the original **v_open** remains intact.

The next function

```
int v_close( viewport *v )
```

closes the viewport and resets it as if it had never been opened. If the underlying text was saved by **v_open,** this function also restores that text. Note that the condition of **saveok** at open time controls whether or not the text is restored when the window is closed.

Deactivate a window by calling

```
int v_deactivate( viewport *v, int hide )
```

A deactivated window can also be closed, in which case the memory used for the viewport snapshot is freed. **v_deactivate** is less thorough than **v_close**. A snapshot of the current contents of the viewport is saved in a local buffer, and if the **hide** argument is true, the original underlying text is restored. The original text is not restored when **hide** is false. A subsequent **v_open** call restores the viewport to its condition before **v_deactivate** was called. If the viewport is hidden, the underlying text is saved again at that time, so text that is written to the screen after the window is hidden is saved correctly when the window is redisplayed.

You can move a deactivated window—in fact, the window must be deactivated before it can be moved. (The move function does this automatically.) The screen will look strange if you move a deactivated (but visible) viewport, however, because the old image will still be on the screen.

Note that, as with **v_close,** the status of **saveok** at open time controls whether or not the underlying text is restored when the viewport is hidden. The **saveok** status at deactivation time is immaterial.

MOVERS AND SHAPERS

The next few functions manipulate viewports. The first is

```
int v_size( viewport *v, unsigned nrows,
            unsigned ncols )
```

This function changes the size of a viewport. It is usually called at least once before the initial display—after the **v_construct** call but before the **v_open**—in order to size the window down from the entire screen. You can call the function at other times, but the window must be closed (not just deactivated). If the window is open when you call **v_size,** it returns an error condition (0) and does nothing.

You can change the position of the viewport on the screen with a call to

```
int v_move( viewport *v, unsigned row,
            unsigned col )
```

The viewport should be either closed

```
    if( v->magic != VMAGIC )
        return 0;

    if( v->inactive )
        v_open( v );

    v->cur_row = min( row, v->nrows - 1 ); /* truncate to fit in window */
    v->cur_col = min( col, v->ncols - 1 );

    window( v->col+1, v->row+1, v->.>col+v->ncols, v- >row+v->nrows );
    gotoxy( v->cur_col + 1, v->cur_row + 1 );

    return (v->cur_row == row  &&  v->cur_col == col);
}
int v_putc( viewport *v, int c, int move )
{
    /* Overwrite the character on which the viewport's cursor is
     * resting. The cursor position advances one notch if the move
     * argument is true. It won't move past the right edge of the
     * line, however. Note that all characters are printed literally,
     * \n yields a graphics character, it doesn't go to the next line.
     * Return true if the cursor moved (it won't at end of line),
     * false otherwise.
     */

    int outc;
    int col, row;

    if( v->magic != VMAGIC )
        return 0;

    if( v->inactive )
        v_open( v );

    /* output the character. Can't use putch() both because we
     * don't have enough control of the color and because it
     * screws up the cursor if we're writing to the bottom right
     * corner of the screen.
     */

    outc = (c & 0xff) | ((v->bcolor << 4 | v->fcolor) << 8);
    col  = v->col + v->cur_col + 1;
    row  = v->row + v->cur_row + 1;
    puttext( col, row, col, row, &outc );

    return( move ? v_advance(v) : 0 );
}
int v_puts( viewport *v, char *s )
{
    /* Write string to current cursor position. Only that part of the
     * string that will fit on the current line is written. The cursor
     * moves to the character following end of string if it can. If the
     * output string was truncated, it will rest at the far right of the
     * line.  Return false if the string won't fit on the line, so was
     * truncated. Return true otherwise.
     */

    if( v->magic != VMAGIC )
        return 0;
    while( *s )
        if( !v_putc(v, *s++, 1) )
            return 0;
    return 1;
}

int  v_getc( viewport *v )
{
    /* Return the character at the current cursor position in the
     * indicated window, which is activated if necessary. Cursor
     * position doesn't change.
     */

    int c;
    int col, row;

    if( v->magic != VMAGIC )
        return 0;

    if( v->inactive )
        v_open( v );

    col  = v->col + v->cur_col + 1;
    row  = v->row + v->cur_row + 1;
    gettext( col, row, col, row, &c );

    return c & 0xff ;   /* strip attribute when returning */
}

int v_gets( viewport *v, int n, char *s )
{
    /* Copy at most n-1 characters into s, starting at current cursor
     * position into s. Return number of characters read.
     */

    char *start = s;

    if( v->magic != VMAGIC )
        return 0;

    while( --n > 0 ){
        *s++ = v_getc( v );
        if( !v_advance(v) )     /* then we just read the last character */
        {                       /* on the line                          */
            *s = '\0';
            return 0;
        }
    }
    *s = '\0';
    return (s - start);
}
```


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or hidden when moved. As with **v_size**, **v_move** is usually called after the viewport is constructed by **v_construct**, but before it is displayed by **v_open**. If it is open and active, the viewport is deactivated, moved, and then reopened. The routine won't let you move the viewport outside the screen. If you try, the viewport will be placed as close as possible to the specified, illegal position. **v_move** returns true if the viewport ended up where you specified, or false otherwise.

The final movement function is

```
int v_scroll( viewport *v, int up, int left )
```

(I'll include the code for this next time; for now it's on the code disk and BBSs only.) This function scrolls the text in the viewport horizontally or vertically (or both) without moving the viewport itself. The text is moved up by **up** lines and left by **left** lines. The opened-up regions are filled with spaces. The **up** and **left** arguments may be zero or negative. The text moves right if **left** is negative, and down if **up** is negative. The cursor position is not changed by the scroll. This function cannot clear the viewport—if the requested movement is greater than the viewport dimension, **v_scroll** returns false and no movement occurs. To clear, use **v_clear.**

I/O FUNCTIONS

The I/O functions (Listing 4) manipulate the cursor and execute input and output to the viewport. A call to

```
int v_gotorc( viewport *v, unsigned row,
              unsigned col )
```

will position the cursor at the desired viewport-relative row and column (the upper-left corner of the viewport is row zero, column zero). The cursor won't go past the edge of the viewport, however; as with **v_move**, it will go to the nearest legal position. The subroutine returns true if it put the cursor at the specified location, false otherwise. Note that passing in very large **row** and **column** arguments is a convenient way to get to the viewport's bottom-right corner. Just ignore the error-return code.

Two output functions are provided.

```
int v_putc( viewport *v, int c, int move )
```

overwrites the character at the cursor position. The cursor then advances one notch if the **move** argument is true (but it won't move past the right edge). Note that all characters are printed literally. For example, '**\n**' yields an IBM graphics character—it doesn't go to the next line. **v_putc** returns true if **move** is true and if the cursor moved. Otherwise, it returns false.

The function

```
int v_puts( viewport *v, char *s )
```

writes an entire string to the viewport, starting at the current cursor position, though not past the right edge. If the string is longer than the available space, the extra characters are not printed. False is returned if the output string was truncated, true if it was not.

The final two routines in Listing 4 provide input. The function

```
int  v_getc( viewport *v )
```

returns the character at the current cursor position. The cursor is not moved. The function

```
int v_gets( viewport *v, int n, char *s )
```

copies at most **n**–1 characters into the string pointed to by **s**, starting at the current cursor position and stopping when **n**–1 characters are copied or when the cursor is against the right edge. The routine returns the number of characters actually read.

SO LONG FOR NOW

The code disk for this issue contains a program to test the functions and a makefile for use with the make utility that comes with Borland's compiler. This makefile can be used to create the VIEWPORT.LIB library, which holds all the viewport functions.

That's the display side of things. As you can see, these functions are useful and are, by themselves, adequate for many simple window applications. Next time I'll integrate them with the text-manipulation routines to create a truly useful windowing system.

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Loop unrolling: A RISCy business

A look at a powerful scalar optimization on RISC and CISC processors

By Mark J. Barrenechea

Amdahl's law states that a program's total execution time is rate-limited by its slowest portion—or rather, by a compiler's worst optimization. Because existing programs are usually scalar-bound, not vector-bound, scalar optimizations ("software pipelining" and "loop unrolling") are as important as vector optimizations ("vectorization"). That is to say, vectorized code is still rate-limited to the surrounding scalar code. Scalar and vector optimizations were once restricted to mainframes and supercomputers, but ever since the Intel i860 became popularized on the PC/AT architecture, these optimizations have been migrating to desktop compilers. Vectorization is discussed here solely in terms of its usefulness in defining and clarifying scalability. Instruction scheduling, even though its behavior is synergistic with unrolling, is an important enough topic to be given its own article at a later date. This article will examine only loop unrolling.

THE RISC ARCHITECTURE

Understanding the impact of software pipelining and loop unrolling is inseparable from understanding the RISC architecture—in particular, the i860 microprocessor. The i860 chip has multiple execution units: an integer core unit, a floating-point unit, and a graphics unit. The *integer unit* is the i860 workhorse. It contains the integer registers, fetches both integer and floating-point instructions, and decodes and executes load, store, integer, bit, and control-transfer operations. The *floating-point unit* contains both the floating-point adder and the floating-point multiplier. The adder performs floating-point addition, subtraction, comparison, and conversions. The multiplier performs floating-point and integer multiply and floating-point reciprocal operations. The *graphics unit* has a special 64-bit integer logic that allows it to operate on long integers, along with a set of special graphics instructions for 3-D algorithms.

The i860 can execute one instruction per cycle as long as there are no register (source vs. destination) conflicts between adjacent instructions. The i860 processor also has a dual-instruction mode that can simultaneously ("in parallel") execute an instruction on any of the three execution units. Additionally, a pair of instructions can execute simultaneously within the floating-point unit, because the adder and multiplier units can operate in parallel. Thus, the i860 can execute as many as four instructions in one clock cycle. The art of keeping these instructions executing harmonically—one per cycle, or optimally, as many as four per cycle in dual-instruction mode—is called *software pipelining*. Figure 1 shows a series of operations that can be performed either in scalar or vector ("pipeline") mode [Reference 1].

In the scalar example, one instruction per cycle is executed (i.e., five instructions in five cycles). No delays are encountered because there are no register conflicts between adjacent instructions. The vectorized sequence executes eight instructions in two cycles by using the adder pipeline. Note, however, that code size increases 62.5% (eight vs. five instructions).

WORKING DEFINITIONS

No agreed-on definitions exist for scalability and vectorization. In the absence of any rigorous definition, categorizing a process as "scalar" or "vectored" is about as descriptive as calling it "modern" [2]. A useful working definition—based on current compiler methodologies—is this: the way a compiler translates high-level source code into assembly instructions determines whether a program has been vectorized or scalar-optimized.

On architectures such as the Intel i860's, there are no explicit vector instructions or registers. On other architectures, such as Cray's, there exist multiple register banks (scalar and vector) and multiple instruction sets (scalar and vector). Yet both types of architectures share similar vector characteristics. They have in common a multistage pipeline that allows for simultaneous instruction execution. Additionally, the i860 can emulate

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high-speed vector registers by keeping variables in its high-speed data cache. The i860 can thus be categorized as a "vector" processor.

Any situation (sequence of code) that a compiler can recognize that uses this pipeline efficiently is considered a vectorized optimization. Any situation a compiler can recognize that uses any other architectural feature—such as the removal of branches or the reordering of instructions—is considered a scalar optimization. Ideally, a compiler automatically accepts code that was written in a higher-level language such as Fortran or C and translates it into vector (pipelined) instructions for the target machine without any need for programmer intervention. This can be achieved using a preprocessor, such as Pacific Sierra's Vector and Array Syntax Translator (VAST), or a front-end compiler flow analysis, as in MicroWay's new vectorizing compilers. Examining the benefits and drawbacks of each approach would require a lengthy discussion.

It's important to identify the most time-consuming portions of an application and then concentrate on optimizing them. These "hot spots" are often found in loops. Consider a simple example:

```
      do 10 i = 1, 50
         a(i) = b(i) + c(i)
         d(i) = a(i) / 2.0
10    continue
```

and its equivalent Fortran 90 array assignment syntax:

```
a(1:50) = b(1:50) + c(1:50)
d(1:50) = a(1:50) / 2.0
```

This array syntax adds the elements 1 through 50 of **b** and **c** and stores the results in elements 1 through 50, respectively, of **a.** Then the elements 1 through 50 of **a** are divided by 2.0, and the results are stored in elements 1 through 50, respectively, of **d.**

Both scalar and vector code can be generated from this loop. In scalar mode, a compiler can unroll the loop, schedule the instructions, and gain scalar improvements (see Livermore results, below). In vector mode, the loop can be transformed into a series of function calls

```
vadd( a[1], b[1], c[1], 50 )
vdiv( d[1], a[1], 2.0, 50 )
```

to routines that contain highly optimized "vector/pipelined" code for doing vector adds (**vadd**) and divides (**vdiv**). The

FIGURE 1: Operations in scalar and vector mode

Pseudo Operations:

```
f18:f19  <---  f6 + f7
f18      <---  f2 + f3
f17      <---  f5 - f4
f22      <---  f12 - f13
f20:f21  <---  f18:f19 - f10:f11 (where f18:f19 = f6+f7)
```

Scalar Code:

```
fadd.sd     f6, f7, f18;        f18:f19  <---  f6 + f7
fadd.ss     f2, f3, f16;        f16      <---  f2 + f3
fsub.ss     f5, f4, f17;        f17      <---  f5 - f4
fsub.ss     f12, f13, f22;      f22      <---  f12 - f13
fsub.dd     f18, f10, f20;      f20:f21  <---  f18 - f10
```

Vector (Pipelined) Code:

		Adder Pipeline Result		
Instruction	**Stage 1**	**Stage 2**	**Stage 3**	**Result**
pfadd.sd f6, f7, f0	[f6+f7]	?	?	0
pfadd.ss f2, f3, f0	[f2+f3]	[f6+f7]	?	0
pfsub.ss f5, f4, f0	[f5-f4]	[f2+f3]	[f6+f7]	0
pfsub.ss f12, f13, f18	[f12-f13]	[f5-f4]	[f2+f3]	f18:f19=[f6+f7]
pfsub.dd f18, f10, f16	[f18-f10]	[f12-f13]	[f5- f4]	f16=[f2+f3]
pfadd.ss f0, f0, f17	0	[f18-f10]	[f12- f13]	f17=[f5-f4]
pfadd.ss f0, f0, f22	0	0	[f18-f10]	f22=[f12-f13]
pfadd.ss f0, f0, f20	0	0	0	f20:f21=[f18-f10]

ILLUSTRATION BY JIM CARPENTER

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TABLE 1: i860 unrolling results

Unroll Factor	Harmonic Mean	Median Rate	Code Size	Compile Speed
0	1.67	1.88	143,000	4:35
2	4.97	5.90	150,000	5:40
4	5.02	6.32	154,000	7:01
8	**5.24***	6.89	161,000	9:10
16	5.24	**7.28***	175,000	15:77
32	5.09	6.86	207,000	26:88
64	4.86	6.53	268,000	56:12

Harmonic mean and median rate are in MFLOPS.
Code size is in bytes.
Compile speed is in minutes:seconds
*Bold values represent the best number for the given unroll factor.

AN ACCURATE MEASURE

An average of execution times that measures total execution time is called the arithmetic mean. Consider

$$1/n \sum_{i=1}^{n} \text{Time}_i$$

where Time_i is the execution time for the ith program in a series of n. If performance (the number of floating-point operations performed) is expressed as a rate (such as MFLOPS), then the average measure of the total execution time is called the harmonic mean. Consider

$$n/\sum_{i=1}^{n} 1/\text{Rate}_i$$

where Rate_i is a function of $1/\text{Time}_i$, the execution time for the ith program in a series of n.

The harmonic mean is an accurate measure for Livermore loops in scalar mode [7]: each kernel can be optimized in some manner, and no weighting mechanism is needed to scale the numbers between the optimized and nonoptimized loops. When Livermore loops are vectorized, some kernels cannot be vectorized with current vector technology. Thus, the harmonic mean significantly understates the kernel performance. A weighted harmonic mean is needed to judge vectorized Livermore loops accurately.

compiler could, of course, in-line this code, but because of implementation restrictions it is easier to generate function calls. **vadd** and **vdiv** are called *idioms*—that is, routines found in a vector library. Examples of idioms are dot products and vector arithmetic operations. A compiler recognizes a finite set of these idioms and generates the appropriate sequence of library calls.

In general, when code can be vectorized, vectorization produces faster-executing code than scalar code for any given "hot spot." This will be demonstrated below.

THE PARADIGM

In order to measure the benefits of loop unrolling, a paradigm is needed to compare performance. Livermore Loops are 24 sample routines that emulate typical numeric-intensive programming. Although these routines may not represent real-world programming, they do provide an industry-accepted yardstick by which to measure performance. A brief explanation of each routine can be found on the code disk for this issue.

To focus only on the performance changes attributable to unrolling, superfluous optimizations—such as in-lining, loop rotation, and local and global common-subexpression elimination—have been turned off for these tests.

Although it's difficult to judge the overall effectiveness of a benchmark using a single number, a measure is needed to evaluate the scalar effectiveness. Within Lawrence Livermore loops, one could use many different numbers (geometric mean, harmonic mean, median rate, etc). The harmonic mean (see "An Accurate Measure," at left), a reasonable compromise in scalar mode, is used here [3].

AROUND THE LOOP AND BACK

Loop unrolling is easy to understand. The loop is reorganized as follows:

- The loop body is replicated n times, where n is the number of times the loop is unrolled (typically, four or eight).
- Any index register increment/offset instructions are eliminated from all replicated blocks except the last one. The original increment is multiplied by n. Any load-and-store instructions are adjusted accordingly.
- The code that handles the loop-counter is eliminated from all replicated blocks except for the last one. The original increment is multiplied by n.
- Branch instructions are eliminated from all replicated blocks except the last [4].

Three performance benefits of loop unrolling become evident:

- A significant number of branches are eliminated.
- Redundant instructions between nested loops may be eliminated, reducing the total number of instructions executed.
- If the loop body is small, all or most loop overhead may be reduced.

Eliminating or significantly reducing loop overhead increases loop execution speed.

Other benefits are less obvious. Because a loop is unrolled n times, there are more instructions (n times the number of blocks) to schedule. This improves the likelihood of reducing scheduling delays. This side effect has a great impact on RISC architectures, but less on CISCs such as the Intel 80486. In a pipeline architecture, the penalty paid for control of transfer instructions can be expensive, because a transfer breaks the flow of execution in the execution pipeline. Loop unrolling has three small disadvantages: the increased compilation time, the growth in code size ([loop body size] * [unroll factor −1]), and the complexity of debugging an unrolled loop (see Table 1).

OTHER ISSUES TO PONDER

In determining the efficiency of loop unrolling, two other architectural features must be considered: the number of available registers and the instruction cache size. By itself, unrolling has an innocuous effect on register coloring. However, when coupled with instruction scheduling, unrolling a loop may separate load-and-store operations, prolonging the lifetimes of certain variables that would otherwise die. This separation may also cause the variable to be either colored to different registers (because most architectures have a limited number of registers) or be spilled, thus "deoptimizing" the unrolled loop. The total effect of unrolling and instruction scheduling on register coloring is not yet known.

The instruction cache size must also be considered. What happens if the unrolled loop becomes larger than the instruction cache? Because the loop must be reloaded

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into the instruction cache for each iteration, perhaps the loop should not be unrolled at all. The performance degradation caused by cache misses may outweigh the advantages of unrolling the loop. This impact is minimal on the i860, because refreshing the instruction cache incurs only a one-cycle delay.

UNROLLED EXAMPLES

Loop unrolling (also called *loop linearization*) is demonstrated in the following example, in which:

```
      DO  10  I = 1, 4
         X(I) = I
10    CONTINUE
```

is unrolled four times:

```
      X(1) = 0
      X(2) = 1
      X(3) = 2
      X(4) = 3
```

All loop overhead in this manufactured example has been removed.

Let's consider a more representative program, DAXPY (the name stands for DA times X Plus Y). The key routine used by Gaussian elimination (in the Linpack benchmark) is DAXPY [5]. Consider

```
      DO  10  I = 1, N
              Y(I) = Y(I) + DA * X(I)
10       CONTINUE
```

and its unrolled equivalent:

```
      J = N - MOD(N,4)          ! 4 is the unroll
                                  factor
      DO  10  I = 1, J, 4
         Y(I+0) = Y(I+0) + DA * X(I+0)
         Y(I+1) = Y(I+1) + DA * X(I+1)
         Y(I+2) = Y(I+2) + DA * X(I+2)
         Y(I+3) = Y(I+3) + DA * X(I+3)
10       CONTINUE
```

For any **N** that is divisible by 4 (that is, the unroll factor), rolled and unrolled loops process the same number of array elements. For any **N** that is not divisible by 4, **MOD(N,4)** elements are not accessed. For example, if **N** = 10, two array elements are not accessed in the unrolled portion.

Finally, let's consider a complicated nested **do** loop that cannot be unrolled or vectorized because of the coding style [6]:

```
      DO  10  J = 1, 4
         DO 20  I = 1, N
            C(J,I) = 0.0
20          CONTINUE
         DO 10  K = 1, 4
            DO 10  I = 1, N
               C(J,I) = C(J,I) + A(J,K) * B(K,I)
10       CONTINUE
```

The loop can be optimized in both scalar and vector modes by restructuring the loop as follows:

TABLE 2: Unrolling statistics for the i860

	UNROLLED						
KERNEL	0	2	4	8	16	32	64
1	3.37	10.19	9.95	10.95	**11.23***	9.32	9.12
2	2.44	6.91	6.77	6.91	6.91	6.91	**7.22***
3	2.53	10.73	11.26	11.85	**12.61***	11.85	6.26
4	2.88	8.40	9.13	9.55	9.55	9.55	**10.00***
5	1.75	5.32	5.21	6.41	7.81	8.62	**8.93***
6	1.79	4.02	4.02	**4.13***	**4.13***	4.02	3.82
7	4.21	10.61	10.47	**10.76***	10.61	**10.76***	10.61
8	2.15	7.89	7.89	7.89	7.89	7.89	**7.96***
9	3.08	**8.49***	8.31	8.40	8.40	8.40	8.40
10	0.95	**4.55***	4.44	4.49	4.49	4.49	4.49
11	1.23	4.58	5.73	6.88	7.64	**8.09***	7.64
12	1.29	5.55	6.52	7.49	**8.33***	**8.33***	**8.33***
13	0.96	2.40	2.40	**2.43***	**2.43***	2.40	2.37
14	1.02	**2.62***	**2.60***	**2.62***	**2.62***	**2.62***	**2.62***
15	0.86	**2.99***	**2.99***	**2.99***	**2.99***	**2.99***	**2.99***
16	2.21	**4.14***	3.94	**4.14***	**4.14***	4.04	4.04
17	2.67	**9.25***	9.04	**9.25***	**9.25***	**9.25***	**9.25***
18	1.71	**7.07***	6.98	**7.07***	6.89	6.81	6.81
19	2.05	7.58	7.39	**8.21***	7.77	4.41	3.56
20	2.85	**6.25***	6.13	**6.25***	5.16	5.16	5.16
21	1.18	**3.08***	**3.08***	**3.08***	3.06	2.94	2.94
22	1.56	**3.15***	3.11	**3.15***	**3.15***	3.11	**3.15***
23	1.97	8.51	8.51	**8.64***	**8.64***	**8.64***	8.61
24	1.42	3.29	3.47	**3.91***	3.68	3.68	2.89

*Bold values are the best for a given kernel.
All units are in MFLOPS.

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FIGURE 2: i860 optimizations for Lawrence Livermore loops

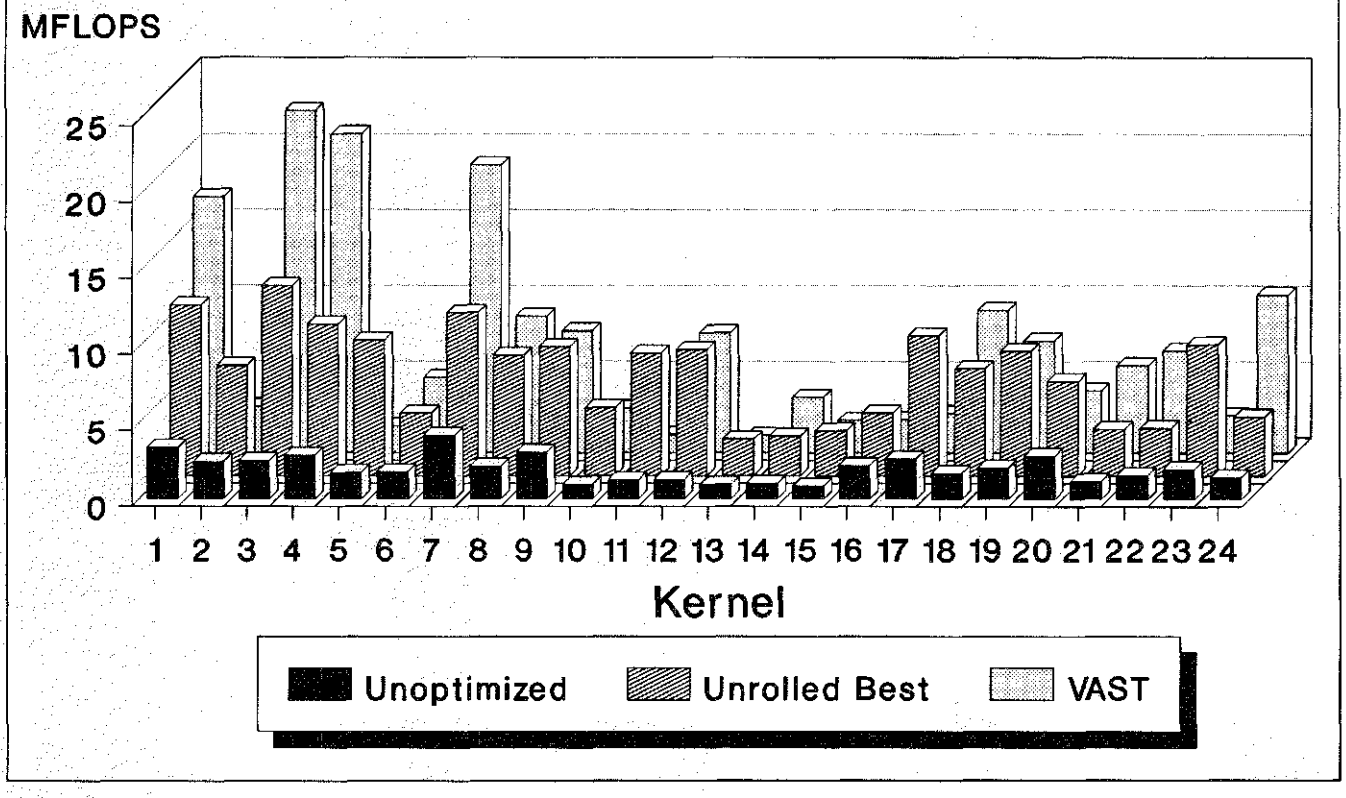
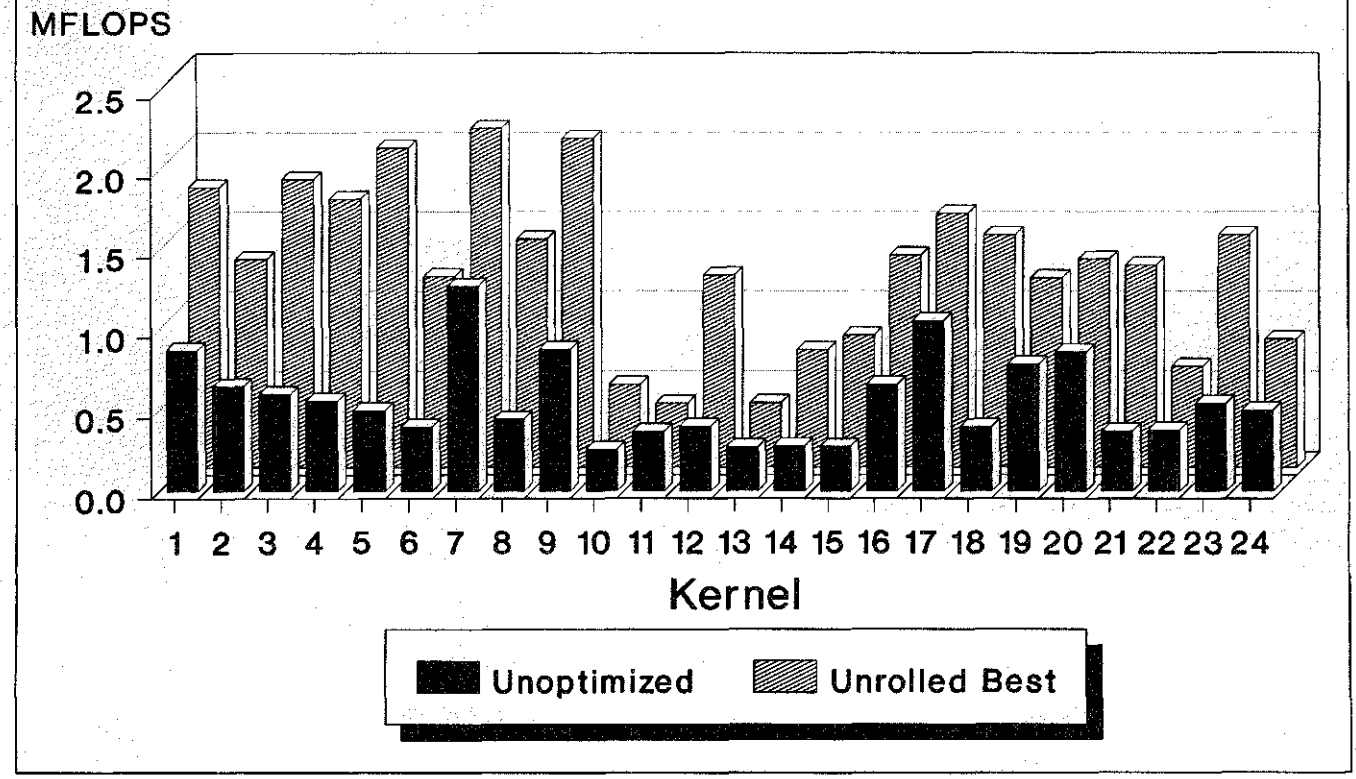


FIGURE 3: i486 optimizations for Lawrence Livermore loops



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```
      DO  10  I = 1, N
         C(1,I) = A(1,1) * B(1,I) + A(1,2) * B(2,I) +
                  A(1,3) * B(3,I) + A(1,4) * B(4,I)
         C(2,I) = A(2,1) * B(1,I) + A(2,2) * B(2,I) +
                  A(2,3) * B(3,I) + A(2,4) * B(4,I)
         C(3,I) = A(3,1) * B(1,I) + A(3,2) * B(2,I) +
                  A(3,3) * B(3,I) + A(3,4) * B(4,I)
         C(4,I) = A(4,1) * B(1,I) + A(4,2) * B(2,I) +
                  A(4,3) * B(3,I) + A(4,4) * B(4,I)
10       CONTINUE
```

This restructuring will outperform the "rolled" version by about a factor of three. Reconstructing existing code is not uncommon when an application is ported from a CISC to RISC/supercomputer architecture.

THE FACTOR FACTOR

Loops get unrolled by a factor of 2, 4, 8, 16, 32, or 64. Typically, loop performance peaks at one of these values. Performance may not improve past this peak value, and may even degrade. A point of diminishing returns is reached for any of the reasons discussed above: data cache overflow, instruction cache overflow, register coloring problems, and the inability to optimize code further.

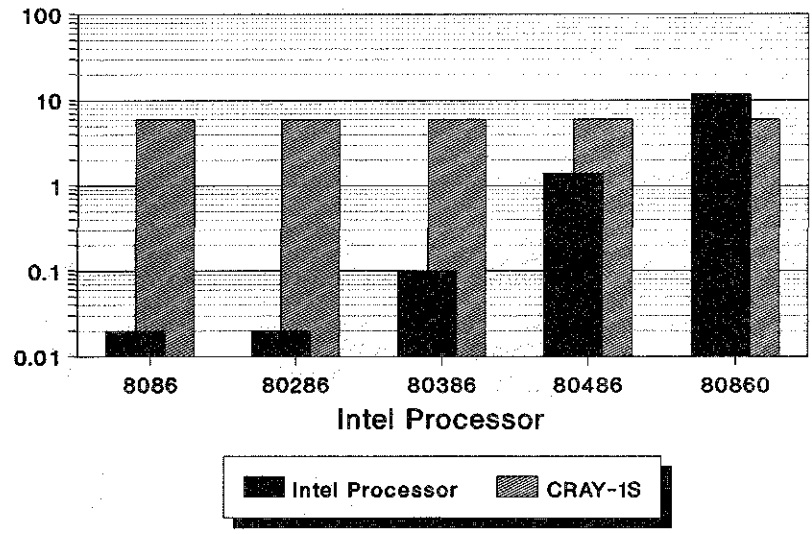
Table 2 (see p. 69) shows the 24 Livermore kernels rolled (0) and unrolled 2, 4, 8, 16, 32, and 64 times. Four patterns emerge from this data. First, all kernels show a significant improvement even after unrolling only twice. Second, for some kernels (2, 4, 5, and 8), a larger unroll factor means greater improvement. Third, for kernels 9, 10, 12, 14, 15, 17, and 22, improvement peaks at some point, and further unrolling provides no improvement. Fourth, for other kernels (1, 3, 6, 7, 11, 13, 16, 18, 19, 20, 21, 23, and 24), unrolling beyond some unroll factor produces a performance penalty. (Note that the kernels 5, 11, 16, 17, and 20 are not vectorizable by VAST.)

What is the optimal unroll factor for a given loop? That depends on which number you use. If you use the harmonic mean, unroll factor 8 wins. If the median rate is used, unroll factor 16 wins. The optimal factor also depends on the loop. As Table 2 shows, it's between 2 and 64 for a given loop; on the average, it's between 8 and 16.

Loop unrolling does require trade-offs: as the unroll factor increases, code size and compilation time also increase (see Table 1). Each programmer must evaluate these trade-offs as they relate to his or her environment.

Considering that optimal loop unrolling depends on the unroll factor, instruction

FIGURE 4: MFLOPS vs. processor performance



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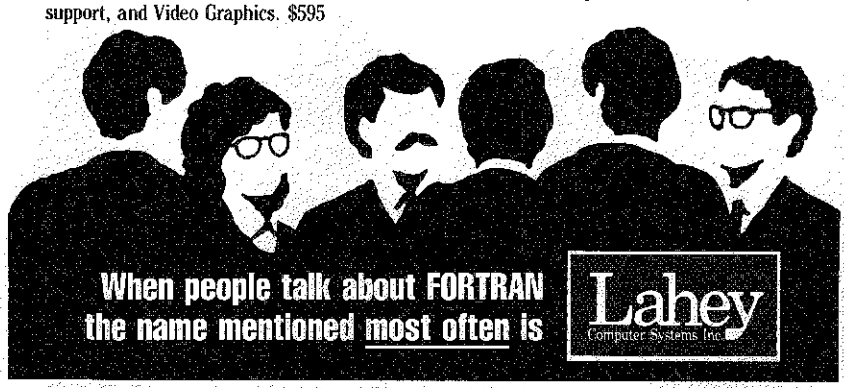

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cache size, number of available registers, code size, and compilation rate, can a compiler determine an optimal unroll factor "on the fly"? To do so, it would unroll a loop using each unroll factor; then it would estimate execution speed. The trade-off would be a logarithmic explosion in compile time. That's why compiler vendors such as MicroWay do not implement this "unroll evaluator." Programmer experimentation is still the best and fastest means of optimizing the unroll factor.

Comparing Figure 2 (i860 results) and Figure 3 (i486 results) (p. 70) supports a claim made above: loop unrolling has better performance gains on a RISC architecture than on a CISC architecture. On the i860, performance improves by a factor of 4.35 (7.2764 / 1.6700). On the i486, the factor is 2.8 (1.3125 / 0.4661).

My work with loop unrolling has led me to draw some firm conclusions: loop unrolling (scalar optimization) can dramatically improve performance. In certain situations, scalar optimizations can rival vector optimizations. Loop unrolling causes trade-offs in code size, compilation speed, and performance. And a point of diminishing returns is reached when loops are unrolled past some factor.

THE RACE IS ON

The Intel i860 breaks a barrier for PC computing. It is the first generally available CPU for desktop computers that outperforms a CRAY-1 (see Figure 4, p. 71). This architecture will change the course of application development and numerical experimentation in the 1990s.

PC programmers can now begin to explore applications such as weather forecasting and ocean flow analysis—experimentation that has not been available to many programmers because of the cost of traditional supercomputers.

Additionally, the i860 creates new opportunities for compiler vendors—and obstacles for some—in the arena of optimization. The i860 is fast when unoptimized, very fast when scalar-optimized, and "CRAY-like" when vector-optimized—demonstrating, again, that understanding program optimization is imperative to obtaining peak performance from a platform.

TEST ENVIRONMENT

All Lawrence Livermore loop numbers presented in this article were produced out of the box in single precision. This benchmark is distributed with NDP-FORTRAN, by MicroWay. The numbers were obtained using a 40-MHz, 32-MB i860 NumberSmasher running under Interactive Unix, hosted on a 16-MB, 33-MHz i486 NumberSmasher. To reflect a real-world program, the i860 clock was *not* turned off. Had the interrupt timer been disabled, the kernel numbers would have been inflated by 10–15%. PJ

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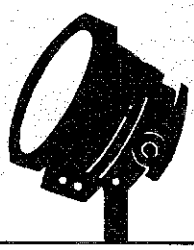

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6. Levesque, J. M., and Williamson, J. W. (1989). *A Guidebook to FORTRAN on Supercomputers*. San Diego, CA: Academic Press, Inc.
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ADDITIONAL READING

- Intel Corporation (1990). *i860 Microprocessor Programmer's Reference Manual*.

NOTE: Use of Livermore Loops is granted with the request that a copy of any results be sent to their author. Send to F. H. McMahon, Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, CA 94550.

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Data structure imperatives

Data structures and algorithms can boost your programming power

By Richard Riehle

I once worked for a boss who, when he had to lay people off, would call in each employee and say, "I want to talk to you about your career." Well, I want to talk to you about your career.

Graphs, trees, lists, queues, stacks, rings, maps: these are some of the common data structures required for the development of non-trivial software systems. Unfortunately, many programmers do not know how to implement such structures. I know of one programmer who fulfilled a requirement of an embedded-systems project with a linked list when he should have used a binary search tree. Because he didn't know how to write a binary search tree algorithm, the program correctly produced the desired result, but not as efficiently as it could have.

WHO NEEDS TO KNOW?

Most undergraduate computer science programs require a course in data structures. But many career programmers have developed their skill through experience rather than through formal education.

Information systems programmers are especially deficient in their knowledge of data structures and fundamental algorithms. MIS programmers often have no idea how to code a stack. Consequently, code for commercial systems tends to be both trivial and unnecessarily complex.

COBOL programmers also have been weak in this area because COBOL cannot support high-quality data structure algorithms, and coding methods for such systems tend to be derived from anecdotal rather than published algorithms. The COBOL designers had no idea that it would be useful to have a pointer data type. But without pointers, it is nearly impossible to create a dynamic structure such as a linked list. COBOL programs are thus limited largely to file-processing problems. FORTRAN 77 and BASIC also fail to provide pointer data types—a common problem with many older languages.

The example of the programmer who used a linked list instead of a binary search tree is all too familiar. In this case, it was not apparent from the requirements statement that the module should have been coded as a binary tree using an in-order algorithm. Some kind of dynamic structure was required, and the programmer did not have sufficient knowledge of data structures to select the correct solution. The program's language could have supported nearly any standard data structure.

Learning about data structures and their algorithms is definitely a career move. Without a knowledge of data structures, you're working without a complete set of tools. The preferred solution to a problem may be a doubly linked ring, but if you do not know the characteristics and algorithmic qualities of that structure, the software solution may work—and still not be ideal.

TEST YOUR EXPERTISE

Suppose you want to write a word processing package. How would you organize the lines of text and the words in each line? Remember that the user will need to insert and delete lines as well as words within lines. Moreover, you need a method to copy and move blocks of text and do rapid search and replacement. You also want to limit storage space so that the program can operate effectively using a minimum (read 640K) of memory. For example, when the user creates clipboard entries, each should occupy no additional space. Maybe you want the cursor to wrap around to the first line of text when you try to "arrow-down" beyond the last line. Would you implement this with a singly linked list, doubly linked list, doubly linked ring, binary tree, or graph? Which data structure would best represent the words for each text line? Now, include a parser to tokenize the elements of each line of text according to a predefined order. Which data structure would you use?

This problem would require, at minimum, a language that supports dynamic data types in the form of pointers. This eliminates COBOL, FORTRAN 77, BASIC, and 4GLs. The problem could be

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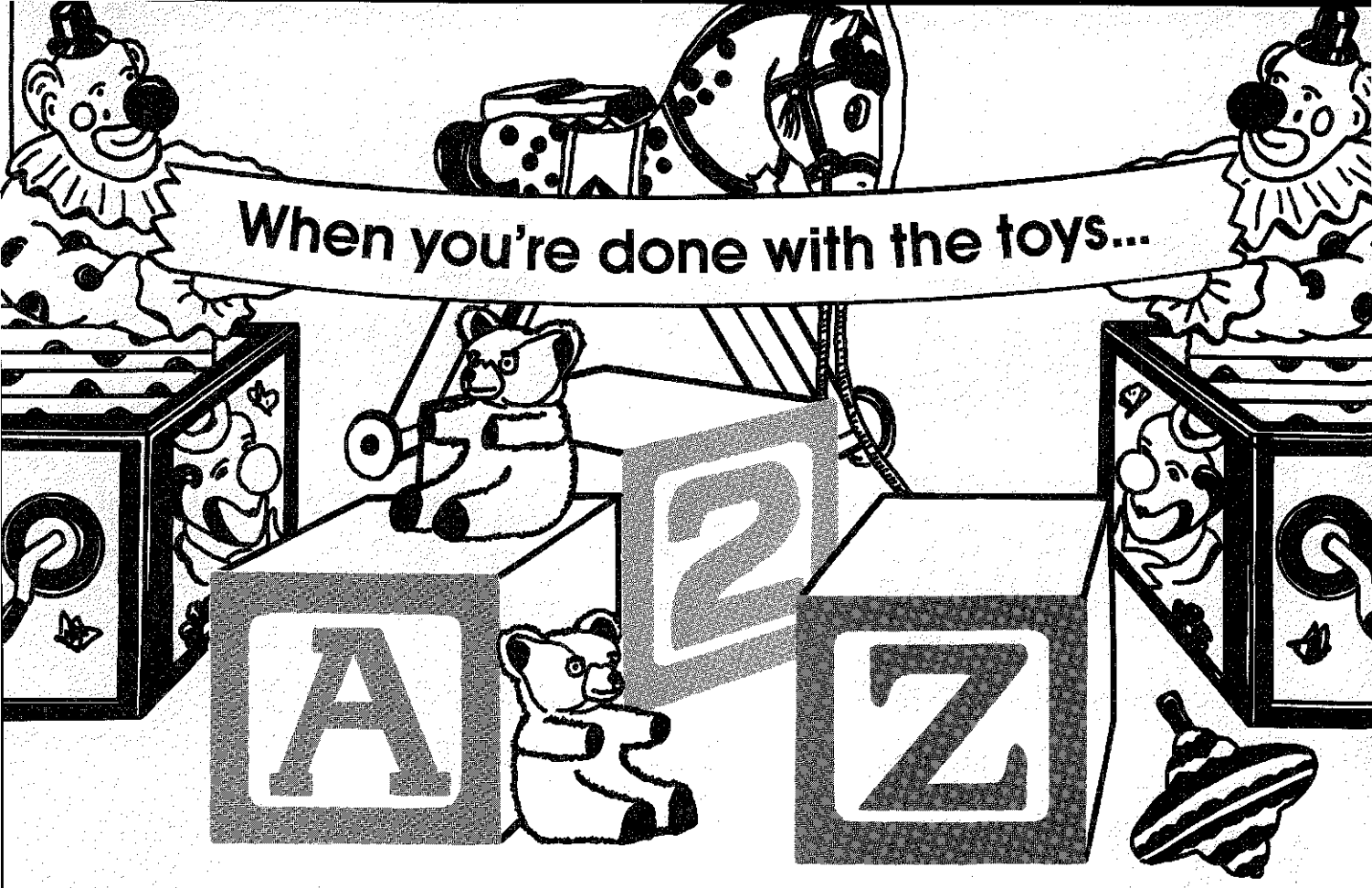

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solved without pointers, but not efficiently. (Of course, we could code it in assembly language.)

The issue is critical in embedded systems. In that growing domain, storage devices such as disk drives are seldom available; all information is stored in primary memory. Selecting the right data structure is crucial to effective implementation.

New languages—starting with PL/1 and moving to Pascal, C, Modula-2, Ada, and now even Fortran 90—provide the capabilities for implementing data structures. Each includes recursion as well as a powerful mechanism for indirect addressing: a pointer type. Pointers are required for C, but even C programmers are often ignorant of fundamental algorithms. Pascal programmers usually learn how to code a singly linked list in their first class, but beyond that they tend to get lost.

MOVING UP THE TREE

Learn as much as possible about structures. When you understand, for example, the three standard algorithms for traversing a binary tree, you can approach a whole new class of problems. Then you can proceed to the algorithms for balancing binary and *n*-ary trees. Next, tackle B-trees, depth- and breadth-search algorithms, and graph management and traversal.

Try learning how to code a binary tree that keeps itself balanced as new nodes are inserted and deleted, such as an Adelson-Velski and Landis (AVL) tree. Other algorithms balance an entire tree after it has been constructed. Which choice is appropriate? Should you use a recursive algorithm or simple iteration? How should you traverse the tree after it is in place? Of the three common methods for tree traversal (pre-order, in-order, and post-order), which solution calls for which method?

Then try directed and undirected graphs—useful for simulations, critical-path method diagrams, games, and network management. Few programmers can write a graph traversal program; even fewer can write a program to dynamically insert and delete nodes and edges in a graph.

OPPORTUNITY KNOCKS

These aren't academic exercises: data structures are essential for efficient implementation of the emerging applications of robotics and process control. Language parsers, expert systems applications, and complex simulations require a knowledge of data structures.

Business opportunities exist here. Grady Booch has a library of predefined data structure components for C++ and Ada. EVB Software Engineering and others have commercially available data structures in Ada. If you convince the marketplace that you have a sparkling data structure contribution that can be reused easily in real software, you can pick up extra money.

The example (Listings 1 and 2) of a doubly linked ring—written in Ada but understandable to Pascal and Modula-2 programmers—should provide interesting study material. Listing 3 (in C) demonstrates how to traverse a binary tree using an in-order algorithm. If these programs look difficult, you have your work cut out for you. PJ

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```
#include <stdio.h>
char *hello( char *s )
    {
    char buffer[40];
    sprintf( buffer, "Hi %s", s );
    return buffer;
    }
```

Assuming that the argument string is never greater than 20 characters there is, nonetheless, a subtle bug in this C function. Can you spot it? If not, give us a call. Hint: it "works" some of the time.

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LISTING 1

```
-- PACKAGE SPECIFICATION for a simple doubly linked ring data structure.
-- There are many ways to implement a doubly linked ring. This Ada listing,
-- submitted by one of my undergraduate computer science students, can be
-- improved and made more reliable. Notably, using a counter to control sub-
-- programs that traverse the ring has potential dangers. It might be better
-- to have a "marked" node to serve as the starting and ending point for
-- any traversal algorithm. A good data structure on which to experiment.

with TEXT_IO;
generic.    -- define generic formal parameters
     type DLRing_Type is private;
     with function  EQUAL (LEFT, RIGHT : DLRing_Type) return BOOLEAN;

package DLRing is
   type DIRECTION_TYPE     is (FORWARD, BACKWARD); -- rotation
   type FINGER_TYPE        is limited private;

   procedure ROTATE   (DIRECTION    : in    DIRECTION_TYPE;
                       FINGER       : in out FINGER_TYPE);
   procedure INSERT   (ITEM         : in     DLRing_Type;
                       FINGER       : in out FINGER_TYPE);
   procedure REPLACE  (ITEM         : in     DLRing_Type;
                       FINGER       : in out FINGER_TYPE);
   procedure DELETE   (FINGER       : in out FINGER_TYPE;
                       EMPTY_ERROR  :    out BOOLEAN);
   procedure PEEK     (ITEM         :    out DLRing_Type;
                       FINGER       : in out FINGER_TYPE;
                       EMPTY_ERROR  :    out BOOLEAN);
   procedure SEARCH   (FINGER       : in out FINGER_TYPE;
                       ITEM         : in     DLRing_Type;
                       FOUND        :    out BOOLEAN);
   function  Is_Count (Finger : Finger_Type) return Natural;

private
         type CELL;                      -- an incomplete type
         type POINTER is access CELL;    -- set up a pointer type
         type FINGER_TYPE is  record     -- keeps track of where
                    PTR  : POINTER;      -- we are in the ring
                    CNTR : NATURAL := 0;
               end record;
end DLRing;
```

LISTING 2

```
-- PACKAGE BODY  Doubly Linked Ring
-- There would be some benefit in adding storage management capability,
-- such as a free list handler, to this package. Also, a storage_error
-- exception would enhance the reliability of the Insert procedure.

package body DLRing is
       ZERO : constant INTEGER := 0;  -- named constant
       type CELL is record
                  ITEM        : DLRing_Type;
                  PREV_CELL   : POINTER;
                  NEXT_CELL   : POINTER;
            end record;

   function Is_Count (Finger : Finger_Type) return Natural is
   begin
        return Finger.Cntr;
   end Is_Count;

   procedure ROTATE   (DIRECTION : in DIRECTION_TYPE;
                       FINGER    : in out FINGER_TYPE) is
   begin  -- ROTATE
      if (DIRECTION = FORWARD) then
```

continued

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```
        FINGER.PTR := FINGER.PTR.NEXT_CELL;
    else
        FINGER.PTR := FINGER.PTR.PREV_CELL;
    end if;
exception
     when CONSTRAINT_ERROR =>
         Text_IO.Put_Line("Constraint Error during Rotate ");
end ROTATE;

procedure INSERT   (ITEM      : in     DLRing_Type;
                    FINGER    : in out FINGER_TYPE) is
          ForWard_Walker  : POINTER;
          BackWard_Walker : POINTER;
begin  -- INSERT
    if FINGER.CNTR = ZERO then
       FINGER.PTR  := new CELL'(ITEM,null, null);
       FINGER.PTR.NEXT_CELL := FINGER.PTR
       FINGER.PTR.PREV_CELL := FINGER.PTR;
    else
       BackWard_Walker  := FINGER.PTR.PREV_CELL;
       ForWard_Walker   := FINGER.PTR;
       FINGER.PTR       := new CELL'(ITEM, BackWard_Walker,
                                     ForWard_Walker);
       BackWard_Walker.NEXT_CELL := FINGER.PTR;
       ForWard_Walker.PREV_CELL  := FINGER.PTR;
    end if;

     FINGER.CNTR := FINGER.CNTR + 1;  -- could be dangerous unless every
                  -- subprogram handles the count in consistent manner.
exception
     when others =>
        Text_IO.Put_Line("Some error during Insert ");
end INSERT;

procedure REPLACE  (ITEM      : in     DLRing_Type;
                    FINGER    : in out FINGER_TYPE) is
begin --  REPLACE
          FINGER.PTR.ITEM  := ITEM;
end REPLACE;

procedure DELETE   (FINGER       : in out FINGER_TYPE;
                    EMPTY_ERROR  :    out BOOLEAN)   is
         BackWard_Walker, ForWard_Walker  : POINTER;
begin
     EMPTY_ERROR := FALSE;
     if FINGER.CNTR  = ZERO  then
        EMPTY_ERROR  := TRUE;
     elsif
        FINGER.CNTR = 1 then
        FINGER.PTR  := null;
        FINGER.CNTR := ZERO;
     else
        BackWard_Walker           := FINGER.PTR.PREV_CELL;
        ForWard_Walker            := FINGER.PTR.NEXT_CELL;
        BackWard_Walker.NEXT_CELL := ForWard_Walker;
        ForWard_Walker.PREV_CELL  := BackWard_Walker;
        FINGER.CNTR               := FINGER.CNTR - 1;
        FINGER.PTR                := ForWard_Walker;
     end if;
end DELETE;

procedure PEEK     (ITEM        :    out DLRing_Type;
                    FINGER      : in out FINGER_TYPE;
                    EMPTY_ERROR :    out BOOLEAN)   is
begin
     if (FINGER.CNTR  /=  ZERO)  then
         ITEM        := FINGER.PTR.ITEM;
         EMPTY_ERROR := FALSE;
     else
         EMPTY_ERROR  := TRUE;
     end if;
exception
     when Constraint_Error =>
        Text_IO.Put_Line("Constraint Error in Peek ");
end PEEK;

procedure SEARCH   (FINGER       : in out FINGER_TYPE;
                    ITEM         : in     DLRing_Type;
                    FOUND        :    out BOOLEAN)   is
          NUMBER : INTEGER := FINGER.CNTR;
begin -- SEARCH
      for I in 1 .. NUMBER  loop
          if (EQUAL(FINGER.PTR.ITEM, ITEM)) then
              FOUND := TRUE;
              return;
          else
              ROTATE(FORWARD, FINGER);
          end if;
      end loop;
      FOUND := FALSE;
      ROTATE(FORWARD, FINGER);
   exception
        when CONSTRAINT_ERROR =>
            Text_IO.Put_Line("Constraint error in Rotate ");
   end SEARCH;
end DLRing;
```

LISTING 3

```
/* A simple binary search tree implementation. A tree is a special case of
the more general structure, the directed graph. A complete implementation
would require more features, including memory management, error handling,
and utility functions. To use a binary search tree in an embedded system ap-
plication, it would be necessary to include a "free list" handling func-
tion. This algorithm does not include a capability to keep the nodes of the
tree balanced. Consequently, a realistic implementation would also include
some balancing algorithm such as the AVL method. */

#include <stdio.h>
typedef struct NODE {
        int    data;
        struct node  *left;
        struct node  *right};
#define TREESIZE 100
#define NUL 0
void filltree(struct *NODE), inorder(struct *NODE), postorder(struct *NODE);
int getnumber();

void main() {
{
    struct NODE numbers[TREESIZE];
    filltree(numbers);     /* insert items into tree */
    inorder(number);       /* display tree using inorder traversal */
    postorder(number);     /* display tree using postorder traversal */
}
void filltree (struct NODE *tree) {
    int index = 0;
    int num;
    while ((num=getnumber()) != -1) {
        tree[index].data  = num;
        tree[index].left  = tree[index].right = NUL;
        if (index > 0) insert (tree, &tree[index]);
        index++;
    }
}
int getnumber() {
    int num;
    printf("\n Enter Positive Integer (-1 to end): ");
    scanf("%d", &num);
    return(num);
}
insert (struct NODE *tree, struct NODE *newnode) {
   if (newnode -> data < tree -> data) {
       if (tree -> left == NUL)
          tree -> left = newnode;
       else
          insert (tree -> left, newnode);
   }
   else {
       if (tree -> right == NUL)
          tree -> right = newnode;
       else
          insert (tree -> right, newnode);
   }
 void inorder (struct NODE *tree)  {    /* notice the placement of printf */
   if (tree -> left != NUL)
       inorder (tree -> left);        /* call left child again      */
   printf ("%d\n", tree -> data);     /* visit the node             */
   if (tree -> right != NUL)
       inorder (tree -> right);       /* call right child again     */
}
void postorder (struct NODE *tree)  {  /* notice the placement of printf */
   if (tree -> left != NUL)        /* call left child again       */
       postorder (tree -> left);
   if (tree -> right != NUL)
       postorder (tree -> right);  /* call right child again      */
   printf ("%d\n", tree -> data);  /* visit the node              */
 }
```


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Text filters in BASIC

User-friendly data transformation without pain or strain

By Murray L. Lesser

Although its inventors may not have intended as much, BASIC has become an ideal programming language for writing text filters. Unlike other compiled languages, BASIC offers the combination of automatic variable-length string management, inherent complex string operations, automatic management of input/output file buffers (with sizes specified in the file OPEN statements), and automatic error detection. Also, not by coincidence, BASIC sequential files are identical to DOS ASCII (text) files. The programmer need not worry about handling any of these necessary nuisances explicitly, and the language support will take care of all the exception cases. The only requirement for writing a text filter, beyond implementing the filter algorithm correctly, is to have a pleasing user interface that includes enough "progress report" display output to identify the source of any BASIC error reports if the program terminates unexpectedly.

To illustrate, I have made a small filter to remove the effects of a subtle, date-sensitive bug that was introduced with Microsoft's MASM version 5.1. This bug infects the first line of each page header in the output listing (LST) file, but only on 81 days of each year. If the month and day can each be represented by a single digit (e.g., 4/1/92), the bug inserts an extra <LF> symbol in front of the DOS ASCII EOL symbol (the <CR><LF> pair) that marks the end of that header line.

For historic (compatibility) reasons, Microsoft BASIC parses the <LF><CR> pair as a line-continuation symbol. Thus, when a listing utility written in BASIC reads a bug-infested listing file, the two header lines on each page are concatenated into a single text line containing the embedded three-symbol sequence <LF><CR><LF>. On LPRINTed output, these symbols insert two blank lines between the two header lines. (A listing utility written in C would not concatenate the two lines but would insert one blank line on output.)

DEFENSIVE, BUT FRIENDLY

In computerese, a *filter* is a program with one input and one output that performs a useful transformation on data as it passes through. Some authorities (including the authors of the IBM *Disk Operating System* manual) have complicated this simple definition by insisting that filters should be programmed to read from standard input (the keyboard) and write to standard output (the display screen), thereby requiring the hapless user to specify redirection in each direction every time the filter is run.

My BASIC filters read an input file that has been specified directly as a command-line parameter. This allows a bit of defensive programming to be included, which would not be feasible if redirection were required. Because STRIPIT.BAS (Listing 1) is used only with MASM listing files, it won't even try to read files having any other extension. This means that the input file extension can be omitted from the calling command line. For further user friendliness, most of my text filters do not require any output file name to be specified; they write to a file whose name is derived from that of the input file. If no runtime errors have occurred, STRIPIT's output file has the same name as, and replaces, the input file.

Because BASIC's LINE INPUT statement usually removes the EOL symbols on input, a <LF> symbol will be found only if the two header text files have been concatenated. STRIPIT looks for the first <LF> in the line and removes it if found. The remaining embedded EOL symbol pair causes the concatenated header lines to appear in the output file as two separated text lines.

STRIPIT looks for this extraneous <LF> symbol only in the first header line on each page, which is identified by a <FF> symbol as the first character in the line. For performance reasons, the test is made by the compound conditional statement

---

Murray L. Lesser is a retired IBM engineer. He has written three books about enhancing various Microsoft BASIC compilers with assembled modules. The most recent, Advanced QuickBASIC 4.0, *was published by Bantam.*

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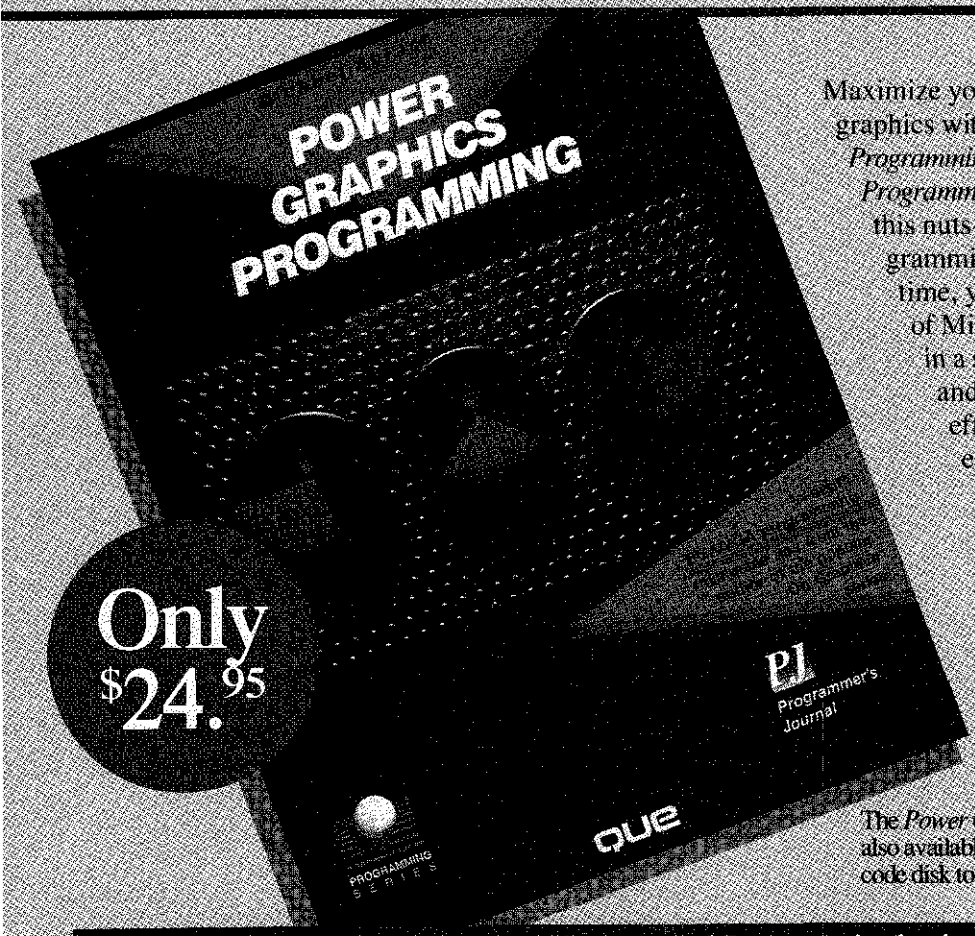

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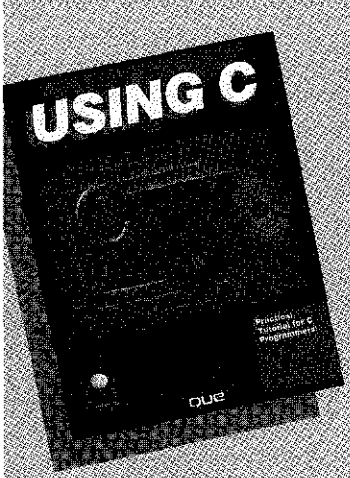

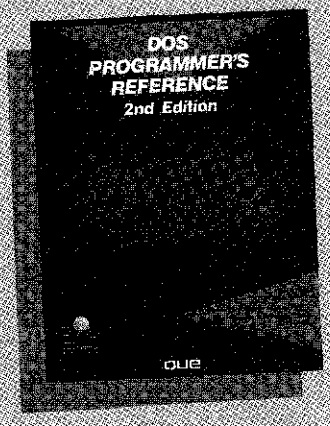

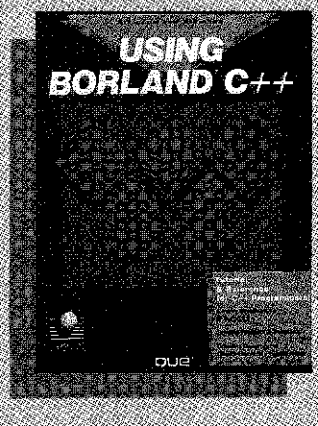

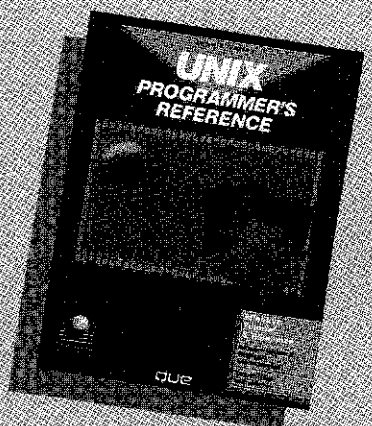

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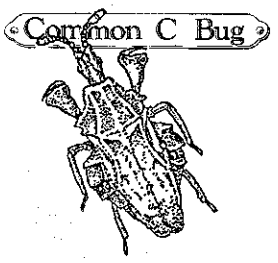

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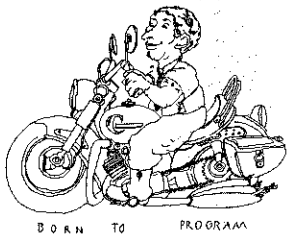

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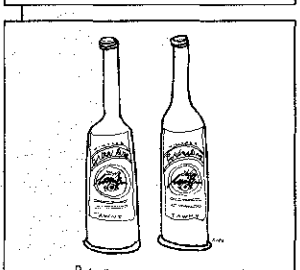

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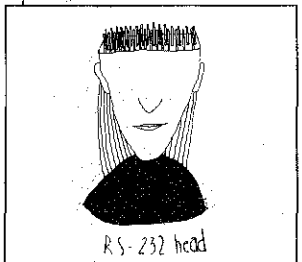

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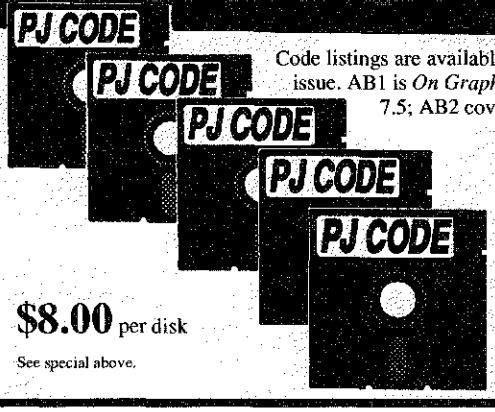

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6.2	7.3	8.4	
6.3	7.4	8.5	

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```
IF LEN(TEXT) <> 0 AND ASC(TEXT) = 12 THEN
```

rather than by the logically equivalent

```
IF LEFT$(TEXT,1) = CHR$(12) THEN
```

The LEN test prevents an attempt by the runtime library code to evaluate the ASC function of a null string, which would force an "Illegal function call" runtime error.

PARDON MY BASIC

This compound conditional statement will not work with BASIC compilers prior to BC 7. Under the BASIC precedence rules in effect before BC 7, *all* relational operators in a statement are evaluated before *any* logical ones, thus forcing the ASC("") runtime error before the preceding AND operator is evaluated. Starting with BC 7, the relational expressions in a compound conditional statement are evaluated left to right only until the final logical outcome is determined. (Unfortunately, this change was not documented in Microsoft's manual, so it is an unadvertised BASIC 7 special.) If you are using the QuickBASIC compiler (BC 4.5), you must change the compound statement to a pair of nested **IF** blocks, as shown in the comments in Listing 1. When compiled with BC 7.1, either the single compound conditional statement or the nested **IF**-block statements will produce the same executable code.

Most PRINT statements in STRIPIT are to display a progress report as the filter operates. Sample output might read:

```
Stripping extraneous <LF>s from FILER.LST
    Renaming FILER.LST to $$$.$$$
    Filtering $$$.$$$ to produce new FILER.LST
        Filtering line 535
    Deleting $$$.$$$
STRIPIT ran to completion.
```

If STRIPIT is unable to complete, the source of the error exit can be determined from the text of the last progress report line and from the text of BASIC's error message. For example, if the input FILER.LST file has the **read only** attribute bit set, the last progress report in the display would be "Deleting $$$.$$$," and the BASIC error message terminating the program would be "Path/File Access Error" (the file would be renamed without changing the attribute bit). Both the renamed input file and the output file (FILER.LST) would be shown in the input directory. If the input file were bug free, the two files would be identical.

Once you have written a text filter in BASIC, writing others is mainly a matter of editing the source code. Most of the executable code is "boilerplate," requiring only minor modification for different input and output file names. The major change is to the filter algorithm—typically, fewer than a third of the executable statements. The BASIC support system does the hard part for you. PJ

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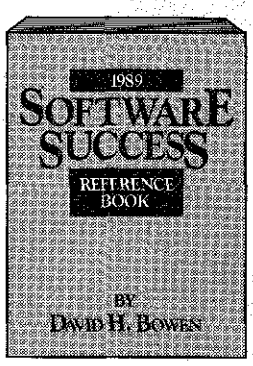

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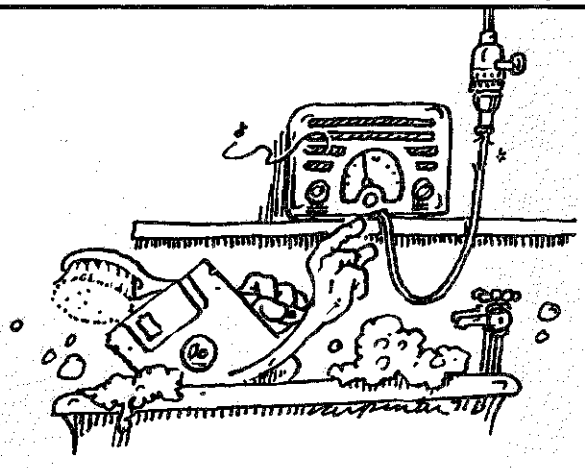
LISTING 1

```
                              STRIPIT.BAS
'     STRIPIT deletes any extraneous <LF> characters inserted into the
' page heading of a MASM listing (LST) file by the bug in MASM 5.10.
' (The erroneous LST files occur only on dates in which both the month
' and the day are given by single digits.)  The original file will be
' replaced by the "stripped" file.
'                    Written by M. L. Lesser, 2/14/91
'            Compiled with Microsoft BC v 7.1, switch "/O"
'   Linked to stub files NOFLTIN, NOCOM, and NOLPT, switches "E/NOE"

   DEFSTR F, T: DEFINT I, L
   LET FILE.OUT = COMMAND$              '<filespec> from command line
   IF LEN(FILE.OUT) = 0 THEN
       PRINT: PRINT "No input <filespec> on command line."
       PRINT "    Usage:  Call with STRIPIT <filespec>"
       PRINT "              where <filespec> is a MASM .LST file."
       END
   END IF
' Force FILE.OUT to have .LST extension:
   LET I = INSTR(FILE.OUT,".")
   IF I <> 0 THEN LET FILE.OUT = LEFT$(FILE.OUT,I)
   LET FILE.OUT = FILE.OUT + ".LST"
   COLOR 2,0                                        'Dealer's choice
   PRINT "Stripping extraneous <LF>s from "; FILE.OUT
   PRINT TAB(5) "Renaming "; FILE.OUT; " to $$$.$$$"
   NAME FILE.OUT AS "$$$.$$$"
   PRINT TAB(5) "Filtering $$$.$$$ to produce new "; FILE.OUT
   OPEN "$$$.$$$" FOR INPUT AS #1 LEN=5120       'Use 5KB buffer
   OPEN FILE.OUT FOR OUTPUT AS #2 LEN=5120
   WHILE NOT EOF(1)
       LINE INPUT #1, TEXT
       IF LEN(TEXT) <> 0 AND ASC(TEXT) = 12 THEN    'Header-line check
' Note:  To prevent an "Illegal function call" runtime error if compiled
'      with BC version 4.5, comment out the statement above this note;
'      use the three commented-out (nested IF block) statements below
         IF LEN(TEXT) <> 0 THEN
           IF ASC(TEXT) = 12 THEN
             LET I = INSTR(TEXT,CHR$(10))          '  (marked by <FF>)
             IF I <> 0 THEN                        '  for extraneous <LF>
                 LET TEXT = LEFT$(TEXT,I-1) + MID$(TEXT,I+1)
                 LET LINE.NO = LINE.NO + 1
             END IF
           END IF
       END IF
       LET LINE.NO = LINE.NO + 1
       LOCATE ,1                                    'Display filter progress
       PRINT TAB(10) "Filtering line" LINE.NO;  ' by overprinting
       PRINT #2, TEXT
   WEND
   PRINT
   CLOSE
   PRINT TAB(5) "Deleting $$$.$$$"
   KILL "$$$.$$$"
   PRINT "STRIPIT ran to completion."
   END
```



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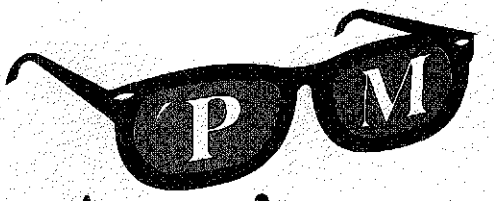

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Network madness

By M. Steven Baker

Network programming is a black hole for many developers. The details of networking software and hardware have been mysterious for a number of reasons. Some vendors remain tight-lipped to protect their proprietary applications. For others, documenting programming interfaces is considered a low priority. Although numerous books cover the intricacies of video hardware, hardly any cover PC network hardware in comparable detail. So I'll review some books that may help you sort out the network madness on your next LAN project. Hoist the nets and prepare to enter a sea of acronyms.

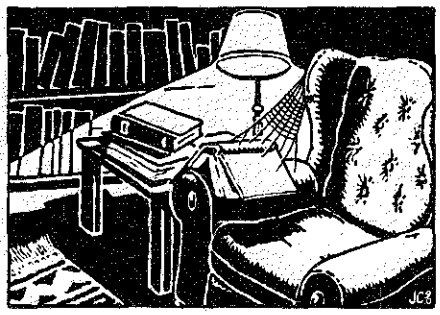

ILLUSTRATION BY JIM CARPENTER

NETWORKING UNDER DOS

Although IBM came out with its first PC network adapter card and software in 1984, documentation on NetBIOS and Server Message Block protocols wasn't really available for many years. An older book that I recommend highly is Sams' 1988 ***C Programmer's Guide to NetBIOS,*** by W. David Schwaderer. The author was a senior IBM programmer and wrote several Big Blue communication products. The book is organized into four parts, beginning with a brief history of IBM's PC LAN hardware and software and an introduction to NetBIOS. The next hundred pages cover NetBIOS support programming in detail.

Part III is an excellent treatise on cyclic redundancy check (CRC) calculations, followed by a reference section (with appendices) on NetBIOS. Bound in the back is a convenient NetBIOS reference card. The book's example programs, written for Microsoft C 5.0, are available on diskette from the author at additional cost. Schwaderer's book is often mentioned by programmers—for example, Phil Katz (of PKARC and PKZIP fame) cites the treatise on CRCs on which the PKZIP CRC implementation is based, and John Otken (crack assembly language programmer) refers to it in this issue's "Spying on NetBIOS." If you need a book that covers NetBIOS, this is still the best one to get.

Well before the arrival of DOS 3 and IBM's network products, Novell was selling NetWare. Although there are many (perhaps too many) books about managing and running NetWare, a paucity exists on programming for NetWare, NetBIOS, and DOS 3.*x* networking. Fortunately, ***Network Programming in C,*** by Barry Nance (Que, 1990), fills this gap admirably. You may be familiar with the author from his activities on BIX (*Byte*'s on-line information network). Nance's book covers network programming using DOS 3.*x* services, NetBIOS, IBM's PC LAN program, the OS/2 LAN Manager, and Novell's NetWare. The book has four major sections. The first covers basic PC networking, multiuser issues in the DOS environment, and PC-to-PC communication concepts. Four higher-level protocols are discussed: Novell's Internet Packet Exchange (IPX) and Sequenced Packet Exchange (SPX)—which were an adaptation of the Xerox Network Standard (XNS)—along with NetBIOS and Server Message Block (SMB), introduced by IBM.

Section II—the heart of the book—discusses network programming techniques. Nance details programming at the DOS level (SHARE and DOS 3.*x* features), using NetBIOS, and using IPX and SPX (NetWare) services. Useful sample code is provided to detect the presence of a LAN. These tests include checking for network disk drives, NetBIOS, NetWare, SHARE, PC LAN, and custom LANs. Code examples illustrate how to identify workstation names and user IDs and also demonstrate file sharing, locking records, and network printer services. Other chapters in Section II cover NetBIOS, IPX/SPX programming, and program testing and debugging.

Section III is a reference to DOS, PC LAN, Novell, OS/2, NetBIOS, IPX, and SPX functions. Section IV contains source code listings for several larger program examples, along with header files and network error codes. Example programs include a file and record collision tester, a NetBIOS microscope (tester), a remote program executer (and matching remote job-submission program), postman, and electronic mail programs.

Most smaller code fragments are in standard C code, and examples illustrate the differences between Microsoft, Lattice, and Turbo C compilers. The larger programming examples are based on Borland's Turbo C compiler (v2.0) using the in-line assembler. Conveniently, the sample programs are supplied on a disk bound in the back cover. If you can buy only one book on PC network programming, *Network Programming in C* is my recommendation.

Another useful new title is Prentice Hall's ***A C Programmer's Guide to the IBM Token Ring,*** written by William Roetzheim (1991). You may know Bill from his contributions to our "Consulting" column. Although any number of books cover Ethernet hardware, information on IBM's Token Ring has been scarce. This *Guide* is a welcome resource, presenting details on IBM's Token Ring hardware and software in an easy-to-understand, concise form.

Programming for the token ring is covered at varying levels of support. Chapters discuss programming at the hardware level and programming using PC LAN Redirector, NetBIOS, and Data Link Control (DLC) services. The last chapter examines transaction-oriented processing using the PC version of IBM's Application Program-to-Program Communication (APPC/PC). Code fragments in Borland's Turbo C illustrate most features and form the basis of a working library; a companion disk is available from the author. This

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is the only book I've found that covers programming at the DLC and token-ring hardware level. For those who work with "Lord of the Token Rings," this book is recommended highly.

UNIX MEANS NETWORKING

In other environments, networking is taken for granted: Unix is synonymous with networking in many ways. Most of the first experiments with networking were based on Unix, and few Unix systems exist today without some network connection. Even Novell's NetWare protocols are based on Xerox research activities under Unix. Although good resources on DOS networking are scarce, for Unix we have an abundance of good material. I'll discuss some of the best.

Unix Networking, edited by Stephen Kochan and Patrick Woods (Hayden, 1990), is an excellent general overview of network programming in the Unix environment. The book is a collection of writings by expert authors on specific Unix network concepts. Separate chapters cover the Unix-to-Unix Copy Program (UUCP), TCP/IP, Sun NFS and RPC, AT&T STREAMS, AT&T's Transport Layer Interface (TLI) and Remote File System (RFS), OS/2 LANs, networking and the X Window System, and Sun NeWS.

Brian Redman (Bell Labs) begins the book with a useful description of UUCP. Redman was one of the authors of the HoneyDanber version of UUCP, now distributed with AT&T Unix. Douglas Comer (of Xinu fame) and Thomas Narten (Purdue) provide an overview of TCP/IP and the Berkeley socket interface. Douglas Harris (Marquette University) covers the AT&T Unix networking interfaces. These include STREAMS (which was created by Dennis Ritchie), TLI, and RFS. The OS/2 chapter, written by Martin Dunsmuir (Microsoft), discusses LAN Manager/X, including the core SMB and Extended SMB protocols and NetBIOS. Adrian Nye (O'Reilly and Associates) examines networking and the X Window System and X protocol. Louis Delzompo and Owen Densmore (Sun) describe NFS and RPC protocols and summarize the Network Extensible System (NeWS). All in all, *Unix Networking* is an expert overview of networking concepts.

Unix Networking Programming, by W. Richard Stevens of Bell Labs (Prentice Hall, 1990), is a fine textbook. The first few chapters provide a framework for the Unix process model and interprocess communication (IPC), as well as a discussion of networking and various communication protocols. Individual chapters provide details on Berkeley sockets and the AT&T System V Transport Layer Interface. The book also covers networking examples (including network library routines based on 4.3BSD Unix), security, time and date routines, Ping routines, file transfer, line printer spoolers, remote command execution, remote login, remote tape access, and remote procedure calls. A short, interesting chapter compares the performance of various Unix IPC and network mechanisms on a Compaq 386/20, a DEC MicroVax, and an AT&T Unix PC (10-MHz 68010). Although other protocols (such as XNS) are mentioned, most of the focus is on TCP/IP and the Unix network program concepts that are based on it. This practical book cites case studies from actual network applications; its extensive C source code (about 15,000 lines) further facilitates understanding.

NETWORK PROTOCOLS

For many programmers, the beauty is in the details. Although a bit dry, Sams' three-volume ***Handbook of Computer-Communications Standards,*** written by William Stallings, is good starting point for learning network protocols. Volume 1 (second edition, 1990) describes the Open System Interconnection (OSI) model and OSI-related standards. It discusses the now-familiar OSI layered model for communications and protocol details of OSI-related standards at all seven layers, including HDLC, X.25, Internet, transport, session, and presentation services. Volume 2 focuses on LAN hardware standards (IEEE 802 and ANSI), including logical link control (LLC), Ethernet (CSMA/CD), token bus, and token ring. The second edition of Volume 2 (1990) adds information on Ethernet's unshielded twisted pair (10BASET) and fiber-distributed data interfaces (FDDI). Volume 3 covers the TCP/IP protocol suite. It provides a detailed description of some of the protocol standards in this family, including Transmission Control Protocol (TCP), Internet Protocol (IP), Simple Mail Transfer Protocol (SMTP), and TELNET. Volume 3's second edition (1989) adds details on Reverse Address Resolution Protocol (RARP), Exterior Gateway Protocol (EGP), Simple Network Management Protocol (SNMP), and User Datagram Protocol (UDP). You'll find no source code here—just useful narrative descriptions and details on network protocols.

If you're interested in a discussion of programming issues, read Prentice Hall's two-volume second edition of ***Internetworking with TCP/IP,*** by Douglas Comer and David Stevens. These books are based on Comer's earlier books on the Xinu operating system, a Unix workalike. Volume I covers TCP/IP principles, protocols, and architectural concepts, and Volume II focuses on design, implementation, and internals. This volume is illustrated profusely with C code to implement the underlying TCP/IP family protocols. The earlier edition implemented ARP, UDP, and IP code. The current edition enhances this code and adds ICMP and the higher-level TCP and SNMP protocols using a socket-level interface. Be forewarned, though: the network hardware interface is for DEC Ethernet. If you need to understand TCP/IP, these books are an excellent resource.

If your networking activities extend to the Macintosh, Addison-Wesley has two helpful books. ***AppleTalk Network System Overview,*** by Apple Computer (1989), provides a readable overview of Appletalk—Apple's network system. The first part briefly describes AppleTalk hardware and software, and Part II focuses on AppleTalk protocols and applications.

The second edition (1990) of ***Inside AppleTalk,*** by Sidhu, Andrews, and Oppenheimer (of Apple Computer), gives detailed descriptions of the AppleTalk protocol architecture. This reference book covers the physical and data links, data flow, named entities, reliable data delivery, and end-user services. Appendices provide hardware specifications and software details. Like the other books in Addison-Wesley's Apple series, these books are very well produced and easy to read.

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Network debugging and comm libraries

By M. Steven Baker

A simple task often unearths all sorts of interesting and time-consuming distractions. Because of this issue's theme, my plan for this space was to review some network programming software tools and to look at the newer versions of DOS communication libraries. I'll start with the networking tools, because they make a nice connection with the discussion of 386 debuggers in my May/June "Impressions."

WHEN THE GOING GETS TOUGH

Connecting similar machines is occasionally problematic, but working with divergent hardware and software from multiple vendors can create real headaches. I've been working for some time with peer-to-peer network software that allows DOS machines to interconnect with Unix and other platforms. I had intended to review several TCP/IP and socket library packages for this issue, but new releases from FTP, Sun, and NetManage arrived late, so I'll postpone this discussion.

Here at *PJ*, we use peer-to-peer network software for editorial and production. On older 386 machines we run DOS, a memory manager (to free space for network drivers), network software, and memory-intensive applications such as Ventura Publisher and Corel Draw. We occasionally experience problems that cause our network server or workstations to lock. Not being naive, I *know* that most of this software has bugs. But what is at fault—DOS, the memory manager, the network drivers, the application software, or the aging hardware? Software layering makes this even more perplexing.

At home, I network a fast 486/33 with several older machines. I have occasionally managed to lock the 486 by XCOPYing files over the network. No memory managers here, so is it a hardware or software (DOS or network) problem?

When the going gets tough, I reach for **Periscope**'s debuggers. If your work involves hardware or problematic software (device drivers and interrupt-driven functions like comm ports and networks), Periscope's hardware-assisted debuggers can't be beat. The least expensive hardware option is a simple breakout switch (to cause an NMI interrupt) and software (Model II, $225).

In some situations you may need protection for debugging code or a full 640K for programs, so option boards (Model I with 512K, $595) are available with write-protected memory. At the high end, there are pods (Model IV, from $600) that plug into your 286/386/486 socket to provide complete CPU state information—data not available without an expensive in-circuit emulator (ICE). Periscope's latest software debugger (v5.06) even has an option to work with Qualitas's 386MAX (v5.11). The EMS manager provides protected memory for Periscope, minimizing the need for a hardware board. The Periscope software is lean and powerful, with enhanced features when used on 386/486 machines. Their debugger supports Microsoft and Borland symbolic debugging information and .RTLink and PLINK overlays. For debugging device drivers and memory-resident programs, Periscope is an ideal tool.

Another option for tough debugging tasks is the handful of products from Nu-Mega Technologies. Their flagship product, **Soft-ICE** ($386), is a 386 debugger. Soft-ICE puts 386/486 DOS machines into the virtual-8086 mode, allowing control over instruction execution and memory access. Breakpoints can be set on individual port and memory accesses, allowing almost full-speed execution. Soft-ICE supports all sorts of conditional breakpoint parameters as well as I/O logging. The latest version (v2.5) understands Borland's and Microsoft's symbolic debugging information, .RTLink, and LINK overlays. CodeView can be run under their **MagicCV** product with Soft-ICE, freeing DOS memory for your program. Their latest product, **CV/1** ($129), allows debugging with Codeview on a single monitor under Windows 3.

Bounds-Checker ($249) is a valuable virtual-8086 debugging tool that catches out-of-bounds memory accesses while running DOS programs. The user creates exception files to indicate where writes to code segments, DOS, and BIOS areas are allowed. The latest version (v1.1) integrates with Soft-ICE for pop-up debugging when an out-of-bounds action occurs. Nu-Mega has developed a similar program for Novell to debug NetWare 386 Loadable Modules (NLMs).

DEBUGGING NETWORKS

If your work involves heterogeneous networks, you may eventually stumble onto a problem that requires a network protocol analyzer. Most products for analyzing networks bundle hardware (usually a portable 386 computer) with special software—a rather expensive proposition. In the process of reviewing TCP/IP implementations, I worked with FTP Software's **LANWatch** ($995), a software-only product that turns any PC into a LAN analyzer. It's available for Ethernet, StarLAN, and token ring networks—the user must supply an interface card for the network being analyzed.

Let me illustrate LANWatch's use with an example: a friend was trying to integrate several PCs (used as data-entry stations for scanning and registering livestock brands) with a dedicated Unix machine. The custom application was based on an NCR Unix box as a database server using TCP/IP. Once TCP/IP had been installed on both DOS and Unix, simple testing with FTP indicated that small files sent from a PC to Unix containing, say, "abc," ended up doubled ("abcabc"). Which network software was causing the glitch? With conventional tools, it was impossible to tell. With LANWatch, it took all of 10 minutes to log activity during the file transfer and analyze what was taking place. I've also used LANWatch to look at proprietary protocols such as Artisoft's LANtastic over Ethernet. If your problems require a protocol analyzer, I recommend LANWatch highly.

LOW-COST UNIX NETWORKING

Although DOS has many strengths, Unix wins hands down when it comes to networking. Most Unix machines can be considered part of one worldwide network. The Unix community supports a huge exchange of information, digital data, and mail transparently—using dial-up modems

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(UUCP) and dedicated network connections (the Internet). An interesting product for DOS users is **Coherent,** by Mark Williams. This 286 version of a Unix-like clone is priced at a mere $99.

If you want to get your feet wet in the Unix environment, I recommend this product on several accounts. Coherent comes with a solid version of the Unix-to-Unix Copy Program (UUCP), yet it costs less than many comm packages. With UUCP and a friendly Unix host handy, the wealth of information available on the Unix net can now be yours. With UUCP, you queue up requests to send or receive files (mail, regular news forums, or digital data) that are modemed by your computer to a Unix host. The process is automatic and transparent, and it represents much of what Unix has to offer. Because UUCP file transfers are automated, your connect time is minimized: UUCP uses a sliding window protocol that delivers close to line speed in most situations.

Another plus for Coherent is its light overhead. Coherent runs on 286 machines with as little as 640K of memory and 8MB of free hard-disk space. Unlike many 386 Unix implementations, Coherent coexists easily with DOS. Installation takes four floppy disks and about 20 minutes compared with 20 to 80 disks (Unix V Release 4) and half a day. A Coherent disk partition doesn't have to be the first one: their custom boot sector code will default to DOS, or you can choose the partition to boot from by typing a number during the boot process. Files are easily copied to and from DOS floppy and hard disks. All this plus a C compiler and most Unix utility programs, including **lex, yacc, nroff, tar, compress,** and others.

Coherent does have its limitations: the compiler currently supports only the small model (they're working on a 386 version), and it's K&R C, not ANSI. Some hardware devices (such as network cards) are not yet supported. All in all, though, you can't go wrong for the price. One warning: like OS/2, Windows, and Unix, Coherent can consume large quantities of time because it poses a new, interesting challenge for programmers. Don't say I didn't warn you—but by all means try UUCP and Coherent as a window into the Unix world.

COMMUNICATION LIBRARIES

Because several serial communication libraries have been updated recently, I thought it would be challenging to try porting a few of these products to work with DOS extenders. These packages are available with source, so porting can be a test of clean, portable code. New features in comm libraries are in four areas: 16550 FIFO support and UART hardware flow control, file transfer protocols, terminal emulation, and network modem support. It's ironic that vendors are supporting more file transfer protocols at a time when error-correcting modems, which mitigate much of the reason for robust protocols, are becoming the norm.

TABLE 1: Comparison of communication product features

Feature	Async Manager	Essent. Comm	GreenLeaf CommLib	C Comm Toolkit	Solid Link	SilverComm Async	COMM DRV
File Transfer:							
Xmodem	X	X	X	X	X	X	N/A
Ymodem	X	X	X	X	X	X	N/A
Ymodem-G		X	X	X	X	X	N/A
Zmodem			X		X		N/A
Kermit		X	X	X	X		N/A
Sealink/Telink					X		N/A
Hardware/Interface:							
16550 UART	X	X	X	X	X	X	X
Multiport boards		X	X	X		X	X
Network APIs			X			X	X
Handshaking:							
XON/XOFF	X	X	X	X	X	X	X
Hardware	X	X	X	X	X	X	X
Terminal Emulation:							
ANSI		X		X	X	X	N/A
VT100				X	X	X	N/A
Other				X			N/A

ANSI C compilers are a wonderful improvement over K&R, but they don't fully replace a good lint program. I use a variety of C compilers for just this reason. For instance, MetaWare's High C/386 is fussy about C syntax and quiet conversions. This can be very helpful. At other times, you may prefer the raw compile speed and debugging offered by Borland's C++.

My technique for porting comm source code used **PC-Lint 386** from Gimpel Software ($239) as a starting point. This latest version has a bundled-in 386 DOS extender, so there are virtually no limits on file size or modules that can be checked. The package includes the 16-bit version of PC-Lint (for DOS and OS/2) for use under Windows 3.

PC-Lint comes with an extensive set of compiler and library dependency files that handle predefined preprocessor macros, special keywords, and library differences. The program supports an overwhelming number of options to inhibit various error options and to handle memory models, ANSI, libraries, and output. PC-Lint can also output binary lint object modules so that you need to run lint only on files that have changed. There is definitely a steep learning curve in using this product effectively. Once it's mastered, however, its benefits are hard to beat.

The communication products I worked with are listed in "Vendor Information." All but one are comm libraries that support low-level UART controls, serial I/O, file transfer, and terminal emulation. **COMM-DRV** ($89) from Willies' Computer is an interesting, inexpensive, interrupt-driven device driver for comm ports that also supports background communication. When it's used as a device driver, you can read and write to it like any other DOS device. This makes it attractive for hardware control from DOS and extended DOS programs. The ASM source can also be directly linked with your application.

Two years ago, I ported Blaise's Async Manager to 286 and 386 DOS extenders—so I'm familiar with the problems. A professional 286 DOS-extender port is more difficult than one for the 386, because dual interrupt handlers (both real and protected mode) must be used with shared buffers. Otherwise, characters might be dropped while the 286 switches between real and protected mode; the 386/486 switches quickly enough that this isn't a concern. These problems are minimized further if

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16550 chips (with 16 byte FIFOs) are substituted for older 8250/16450 UARTs.

Blaise's **Async Manager** ($189) and Soft Mountain's **Essential Communications Library** ($329) represent the older breed of comm libraries. Both are based on an assembly language TSR that provides low-level comm services (which can also be linked in with your application). The other products are Greenleaf's **CommLib** ($359), SilverWare's **SilverComm** ($249), Magna Carta's **C Communications Toolkit** ($149), and Solid Software's **Solid Link** ($497 with source). Depending on your situation, serial I/O code might be used to handle devices (such as graphics tablets, plotters, etc.), to transfer files, or to emulate a terminal for remote communication. Your own requirements should dictate which product is right for you.

A SIX-PACK OF PACKAGES

Table 1 (p. 87) compares features of these comm packages. No single product has everything. SilverComm is strong on low-level UART control, event timers, and multiport boards. Solid Link supports the most file transfer protocols, interfaces with Modula-2, and is written in assembly language for small size and speed. CommLib offers the best support for multiport serial boards, can talk with some network modem servers, and has by far the best documentation. The C Communications Toolkit has an interface to the Z80SIO UART, supports the DCA/Intel standard (CAS) for talking with FAX boards, and offers a Televideo terminal emulator. Essential Communications is strong on multiport boards and has code to handle background file transfers. Blaise has a product similar to their Async Manager for use with Turbo Pascal.

The library source code for these products consists of a number of C files along with low-level routines in assembly language. The vendors supply source code written for ANSI C. Unfortunately, each vendor's code uses different macros and **typedef**s to handle DOS memory models for portability. Solid Link consists of 340K of ASM source in nine files with only video routines in C (60K). At the other end of the spectrum is Magna Carta's **C Communications Toolkit**, which is almost exclusively C source (310K) with minimal assembly (30K) for the interrupt service routines.

My most difficult problem was converting the complex ASM macro files; the remaining conversion of the ASM code was generally not difficult. I had the fewest ASM problems with C Comm Toolkit (small size), CommLib, and Async Manager. For example, I needed to change only about 30 lines to convert Blaise's large (120K) ASM file into a simple 286 DOS-extender library (with only a protected-mode interrupt handler). For the 386, changes were more time-consuming than difficult. All offsets had to be changed to use 32-bit registers, and the C code often required a more careful review. I had the easiest time with the C code from the two older products—Async Manager and Essential Comm—which had fewer macros. The SilverAsync C code was also easy to work with.

I found Solid Link's library design thoughtful—it used simpler names and fewer routines. It also had the most ASM code to convert—more than I had patience for. Essential Comm Lib also had too much ASM code to convert manually. The C Communications Toolkit used a large comm structure (300+ bytes), which I found awkward, but it did have the least ASM source to convert. Both Greenleaf and SilverWare have hundreds of small routines that require more work for porting but provide detailed control. I found Blaise time-consuming but easy to port. After many arduous days, I have much of Async Manager, SilverComm, and C Comm Toolkit running in 386 protected mode. The others had either ASM files that were too monolithic or troublesome C files. It's clear to me that plenty of serial I/O options are available for 386 DOS. I'll comment on the final results of my porting efforts next time. Until then, stay cool, calm, and connected. PJ

VENDOR INFORMATION

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Atlanta, GA 30361
(800) 722-7006
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Soft-ICE 2.5 & Bounds-Checker 1.1
Nu-Mega Technologies
P.O. Box 7780
Nashua, NH 03060-7780
(603) 888-2386
Circle 170 on Reader Service Card

LANWatch v2.01
FTP Software, Inc.
26 Princess Street
Wakefield, MA 01880-9855
(617) 246-0900
Circle 171 on Reader Service Card

Coherent v3.1
Mark Williams Company
60 Revere Drive
Northbrook, IL 60062
(800) 627-5967
Circle 172 on Reader Service Card

PC Lint 386
Gimpel Software
3207 Hogarth Lane
Collegeville, PA 19426
(215) 584-4261
Circle 173 on Reader Service Card

Async Manager v3.0
Blaise Computing Inc.
819 Bancroft Way
Berkeley, CA 94710
(415) 540-5441
Circle 174 on Reader Service Card

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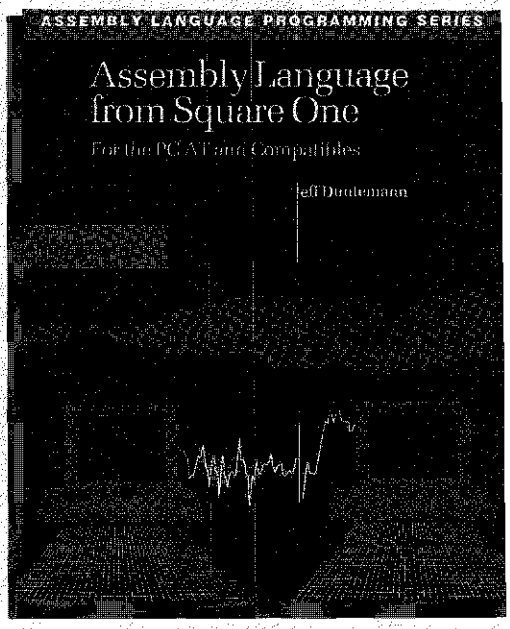

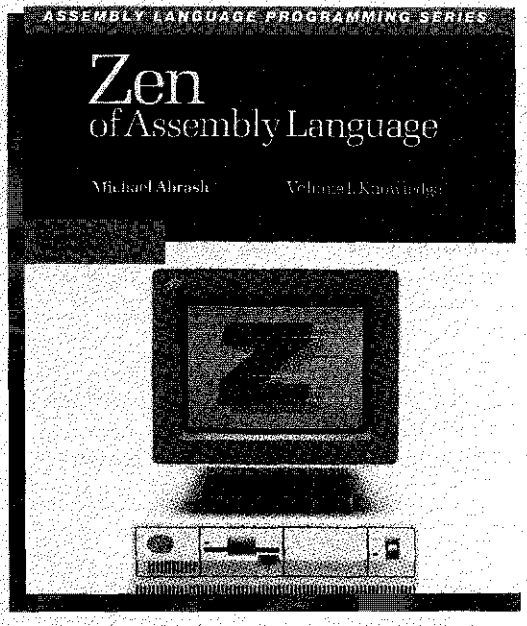

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The **Johns Hopkins University** is conducting its second nationwide Search for Computing Applications to Assist Persons with Disabilities. A $10,000 Grand Prize will be awarded for the best computer program or device that assists persons with disabilities. Other prizes include personal computers and certificates of achievement. Previous winning entries have included the Apple Adaptive Firmware Card, the Reading Machine for the Blind (which converts printed materials into synthetic English speech), and Total Talk, a talking computer terminal for the blind.

The deadline for entries is **August 23, 1991.** For information, contact CAPD, P.O. Box 1200, Laurel, MD 20723, (301) 953-5364.

NETWORK C LIBRARY

The Network C Library from **Automation Software Consultants** provides 300 functions for accessing NetWare system services and statistics. The services include file and directory management, locking, synchronization, bindery management, messaging, printing, queue management, transaction tracking, and diagnostic reports and performance statistics for the file server and individual workstations. Sample programs and documentation are included. The Network C Library is $225 ($450 with source code).

Automation Software Consultants, Inc. (ASCI), 124 Venice Avenue, Cincinnati, OH 45140, (513) 677-0842.

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NEWT AND CHAMELEON

NetManage Inc. has released NEWT, a TCP/IP communications stack for Windows 3, along with Chameleon 2.0, a TCP/IP applications package for Windows. Chameleon is implemented as a DLL and allows users to run concurrent TCP/IP sessions with multiple hosts. Release 2.0 includes Telnet, FTP, Ping, SMTP, and other applications, along with support for Serial Line IP and IP routing. NEWT is $200; Chameleon is $400.

NetManage Inc., 10020 North DeAnza Boulevard, #101, Cupertino, CA 95014, (408) 257-6404.

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MASM 6.0 ARRIVES

Microsoft's Macro Assembler professional development system 6.0 provides high-level language constructs, an *n*-pass assembler, and automatic code optimizations for assembly-language programming. Features include directives that create a high-level procedure interface for defining and calling routines. Compare and flow-control directives automate the implementation of loops and decision structures. MASM 6.0 includes the Programmer's Workbench and supports Windows and OS/2 (versions 1.1 and later). It costs $150; upgrades are $75.

Microsoft Corporation, One Microsoft Way, Redmond, WA 98052-6399, (206) 882-8080.

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DEBUGGER FOR WINDOWS

MultiScope, Inc. has released the MultiScope Debugger for Windows. Both Microsoft Windows 3 and standard character-mode interfaces are available for debugging Windows and DOS applications written using CodeView-compatible compilers. The debugger includes runtime debugging and a postmortem capability that allows analysis after a program crash. Remote debugging allows the debugger to be run on a host computer and the application to run on a remote machine when connected via a serial line or network. MultiScope Debugger for Windows is $379.

MultiScope, Inc., 1235 Pear Avenue, #111, Mountain View, CA 94043, (415) 968-4892.

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VISUAL BASIC AND QUICKWIN

Visual Basic, from **Microsoft,** allows Windows interface components—such as command buttons, text fields, pictures, menus, and file system controls—to be created visually without writing code. The Visual Basic language is derived from the Microsoft QuickBasic environment. It uses a threaded p-code incremental compiler and source-level debugging tools. Visual Basic supports DDE and DLLs. The control set can be extended using C and the Windows SDK and the Visual Basic Control Development Kit, available separately. Visual Basic is $199.

Microsoft's Fortran for Windows 5.1 lets Fortran applications run in the Windows environment by recompiling and linking with the new QuickWin Fortran library. The Fortran compiler supports FORTRAN 77 and a number of IBM, VAX, and Fortran 90 extensions. Version 5.1 includes the Programmer's WorkBench and an extended CodeView debugger. Microsoft Fortran 5.1 is $450.

Microsoft Corporation, One Microsoft Way, Redmond, WA 98052-6399, (206) 882-8080.

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QUICK REFERENCE CARD

Cooper Software is offering a Quick Reference Card for Windows 3. The card provides a list of all 597 Windows procedures, information on which parameters to use, and easy access to the list of manifest constants. The Quick Reference Card is priced at $9.99.

Cooper Software, 3523A Haven Avenue, Menlo Park, CA 94025-1009, (415) 364-9150.

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CASE WITH 3-IN-1 FOR C, C++

3-in-1 C++, a CASE tool for Microsoft Windows, is available from **GUI Computer**. Designed for building object-oriented Windows screens, the 3-in-1 Prototyper includes a screen designer and C++ code generator. The screen designer provides 12 object types. A single command automatically compiles and links the screen. C++ source code and resource, header, and make files are generated automatically. 3-in-1 is priced at $159 (C version), $199 (C++ version), or $259 for both versions.

GUI Computer Inc., 6604 Fernshaw Drive, Dallas, TX 75248, (800) 900-8010.

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GFA-BASIC FOR WINDOWS 3

GFA Software Technologies has introduced GFA-BASIC for Windows 3. GFA-BASIC provides hundreds of BASIC commands, with more than 400 additional commands and functions designed for Windows operations. Users can work with multiple-document interfaces, bitmap file loading, clipboards, DDE, and DLLs. GFA-BASIC allows the use of

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EMS and can run in real or protected mode. C and assembly language routines can be bound into GFA-BASIC programs. GFA-BASIC costs $449 (286 version) or $495 (386 version).

GFA Software Technologies, Inc., 27 Congress Street, Salem, MA 01970, (508) 744-0201.

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SCREEN DESIGN KIT

The Screen Design Kit from **Butler Computer Systems** can be popped up inside applications to show the coordinates and the attribute byte of any position on the screen. A color palette displays available color combinations for color and monochrome monitors. The Screen Design Kit works with any programming language on IBM PCs and compatibles. It costs $99.95.

Butler Computer Systems, P.O. Box 5306, Walnut Creek, CA 94596, (415) 256-8401.

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DATAWINDOWS C LIBRARY

Greenleaf's DataWindows C library, a user interface toolkit, now supports extended DOS 386. Enhanced video routines in C can either access video memory directly or write to the display through calls to BIOS functions. The DataWindows library supports DOS, Unix, Xenix, and OS/2, as well as extended DOS/386. The price is $799.

Greenleaf Software, Inc., 16479 Dallas Parkway, Suite 570, Dallas, TX 75248, (214) 248-2561.

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CODEBASE++ FOR dBASE

CodeBase++ 1.01 from **Sequiter Software** is a multiuser dBASE-compatible class library for C++ programmers. CodeBase++ comes with a DLL for Microsoft Windows 3, allowing development of applications that are compatible with the data, index, and memo files of dBASE III through IV. It can be used with C++ compilers under DOS or OS/2. CodeBase++ costs $295.

Sequiter Software Inc., Suite 209, 9644 - 54 Avenue, Edmonton, Alberta, Canada T6E 5V1, (403) 448-0313.

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B-TREE FILER 5.2

B-Tree Filer 5.2 from **TurboPower Software** is an upgrade of the company's library of database routines for Turbo Pascal. Single-user and network procedures have been merged into one, reducing code size and opportunities for programming errors. EMS memory can be used for index page buffers, freeing up normal DOS memory for other uses. A utility is included that performs many of the changes to convert old files. B-Tree Filer 5.2 is $139 (single-user) or $189 (network). Upgrades are available.

TurboPower Software, P.O. Box 66747, Scotts Valley, CA 95067, (408) 438-8608.

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STORK INSTALLATION SOFTWARE

Island Systems has introduced The Stork installation software. All installation procedures are done using CASE tools, so no programming or script files are required. Because the Stork modularizes the installation definition process, adding product revisions is easy. The Stork uses standard IBM text mode and costs $175.

Island Systems, 7 Mountain Road, Burlington, MA 01803, (617) 273-0421.

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LINNAEUS

Zircel Software offers Linnaeus 1.0, a DOS C++ class browser and application development tool. It builds an information database from any subset of C++ source on multiple disks or directories. Classes or lists of classes can be selected based on regular expressions or on class, parent, or child characteristics. Graphical trees of ancestor and descendant hierarchies are possible, as is detailed class information in windows. Linnaeus works with any C++ source. It costs $195.

Zircel Software, 2285 #A South Jasper Way, Aurora, CO 80013, (303) 750-9543.

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c_pslib C DEVELOPMENT LIBRARY

Barton Creek Software has released c_pslib, a C development library for creating PostScript output. The library implements PostScript calls at three levels: PostScript procedures can be called directly; a midlevel interface handles graphics, text, and loops; and a high-level interface generates full PostScript output. c_pslib costs $195.

Barton Creek Software, 2222 Western Trails, Suite 106, Austin, TX 78745, (512) 441-8354.

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BRIEF 3.1

Solutions Systems is shipping version 3.1 of the BRIEF text editor. New features include mouse support, EMS caching, redo, enhanced window capabilities, dialogue-box support, and support for Microsoft C 6.0 Advisor. BRIEF 3.1 provides a pop-up menu and submenus that can be set to execute commands from within the window on display. BRIEF supports 42 compilers and can be configured to support others. BRIEF 3.1 is $249.

Solutions Systems, 372 Washington Street, Wellesley, MA 02181, (617) 431-7445.

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BBROWSE C BROWSER

The Software Annex has introduced BBROWSE, a C source-code browser that can be accessed from within BRIEF. BBROWSE presents symbol information from all files in a project. Available reports include definitions, references, function and inverted calltrees, unused symbols, and symbol details. The reports serve as home base for hypertext editing. BBROWSE is priced at $89.

The Software Annex, 3143 West 12th Avenue Court, Broomfield, CO 80020, (303) 465-5277.

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FORTRAN-TO-C TRANSLATOR

FORTRAN 77 Programmer's Assistant II from **Microtools** includes a Fortran-to-C translator, a runtime library, and tools to support the conversion and maintenance of C code. The translator generates K&R or ANSI C code, and the library provides more than 200 functions. The Programmer's Assistant II costs $475. The Plus version adds an option to produce structured FORTRAN-8*x* output; it costs $625.

Microtools, Box 2745, Santa Clara, CA 95055-2745, (408) 296-3478.

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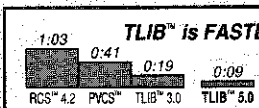

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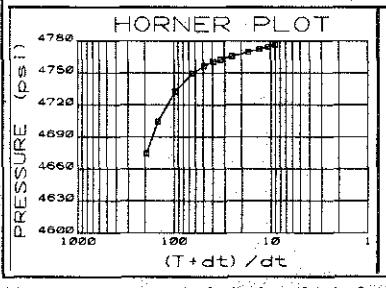

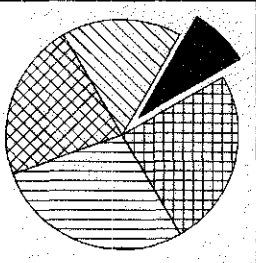

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Benchmark SPECulations

By Hal W. Hardenbergh

Two years ago, a group of Unix computer systems manufacturers got together and agreed to a standardized benchmark. This group was led by the folks building systems based on the classic RISC CPUs—the SPARC, MIPS, and 88000 chips. Each expected to have the best performance.

Their consortium, known as the Systems Performance Evaluation Cooperative (SPEC), wanted to provide a single-number measure of the performance of commercial Unix-based computer systems. This single number, called a SPECmark, is the geometric mean of 10 real-world, public domain application programs that run in compiled C. Four of these programs are considered integer-only, and the other six are floating-point-intensive to varying degrees. All exercise the CPU, cache, and DRAM memory. None exercises the disk, screen, or other forms of I/O. The SPECmark number is normalized to the VAX 11/780; a SPECmark of 12 means that the system is 12 times faster than the 11/780.

The quarterly SPEC newsletter publishes the results of the 10 benchmarks, as well as their harmonic mean. Although such an industry consortium is legal under U.S. antitrust laws, it's not legal for such consortia to provide prices. So the SPECmarks of Control Data CYBER mainframes, Stardent superminis, and PC clones are published side by side. Unless one knows all the prices, one cannot infer price–performance data.

Interestingly, the manufacturer has to provide SPEC—on a standard Unix tape format—a copy of the public domain programs that constitute the suite. The compiler, revision level, and system tuning parameters must be specified. And *anybody* can purchase a copy of the tape! *Cheating is encouraged!* Any increase in performance will benefit the end user, and that's what benchmarks are for, right? So there you have it, folks: a perfect benchmark for CPU performance running compiled C under the Unix operating system.

The second SPEC newsletter (*Winter '90*) revealed that the best (and most expensive) SPARC, MIPS, and 88000 systems scored 17.6, 17.6, and 17.8, respectively. So much for visions of industry superiority. That was 18 months ago. Sigh. The thing about benchmarks is that people learn how to cheat on them early on, and they cheat often. The first cheat was to bundle up 100 poorly performing systems in close proximity and to tie a piece of kite-string around the group. This created a multiprocessor system with a "throughput" that is 100 times greater, but is no faster for any one user. This heresy was quickly shunted aside with a "throughput" SPECmark, which is ignored by everybody except systems administrators.

ILLUSTRATION BY JIM CARPENTER

The next two heresies occurred more or less concurrently. Observing that all current-generation systems have about the same integer performance, Intel publicized the performance of the i486 based on the integer-intensive subset of the SPEC benchmark suite. This performance (18.2 MIPS for a 486/33) is very close to that of the more-expensive RISC boxes and considerably superior to that of the less-costly RISC boxes that people actually buy. Sun's IPC racks up 9.6, the SPARCstation 1+, 12.4, and the DECstation 3100, 11.8. The RISC vendors, led by MIPS, screamed bloody murder.

While the RISC folks were frantically trying to shore up their integer flank, IBM nuked their floating-point flank. The bomb was the RS6000 model 320—$12,900 with disk—with an overall SPECmark of 24.6. It got that mark by turning in an outstanding performance of 32.4 in the fp-intensive portion of the suite, while providing integer performance lower (!) than that of the 486/33. And the RS6000's price was a *lot* lower than those of the faster systems offered by other RISC vendors.

The traditional RISC vendors, led by MIPS, wailed that IBM unfairly emphasized fp performance. Actually, IBM did no such thing; the RS6000 performance was reported in full conformance with the rules and procedures set up previously by SPEC and approved by all members, including MIPS. The RS6000's secret is its ability to do an fp multiply-accumulate in a single clock cycle, an ability shared by three different DSP chips and by the i860 (if you assume the i860 is not a DSP chip).

While the traditional RISC vendors frantically looked for a way to disqualify the 486 and RS6000, HP was preparing to slam-dunk the entire field with their diskless $12,000 "snake" model. The HP system has an implementation that is flatteringly similar to the RS6000's, but a SPECmark of 42.5! To improve performance, HP used a faster clock and an integer unit that effectively executes two instructions per clock by using very complex integer instructions. That means "snake" has about equal integer and fp performance.

A vast silence now emanates from the traditional RISC camp. They're beginning to regret placing the RISC label on the RS6000 and "snake." These two units have superior performance because they are more complex than the simplistic RISC chips and hence get more work done per clock cycle! The SPARC, MIPS, and 88000 are demonstrably inferior computing engines. We have the SPEC benchmarks, officially approved by the RISC folk, to prove that point conclusively.

I wonder what the traditional RISC camp will do about Intel's 100-MHz 486 working prototype, with its potential integer SPECmark of 55 or so? Furthermore, does the thought of Intel's upcoming 586 give the RISC folks nightmares?

Benchmarks are ever so much fun. PJ

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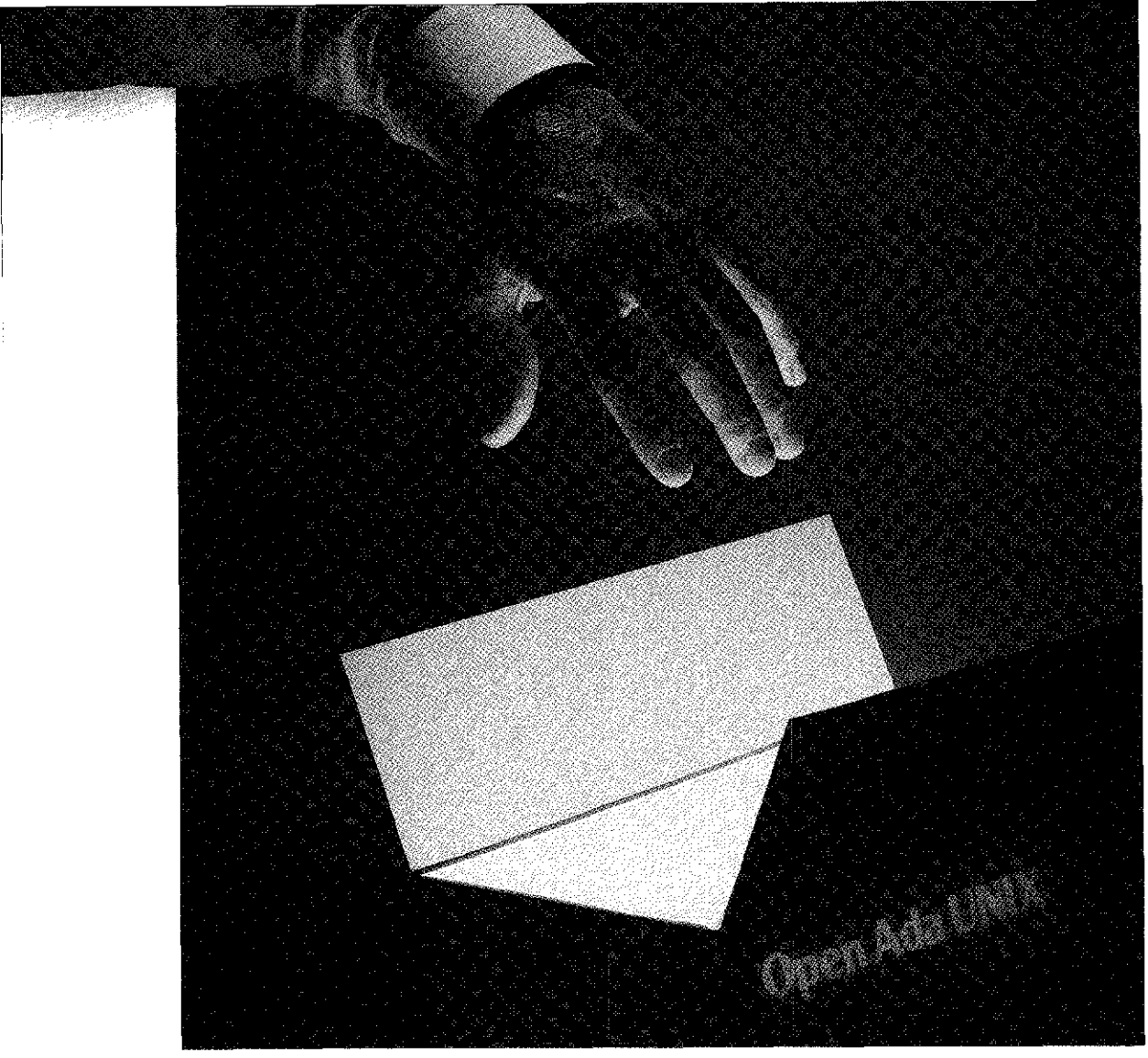

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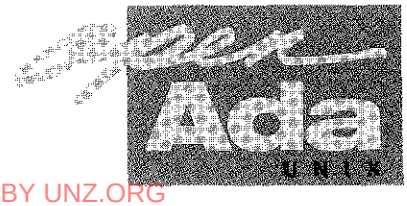

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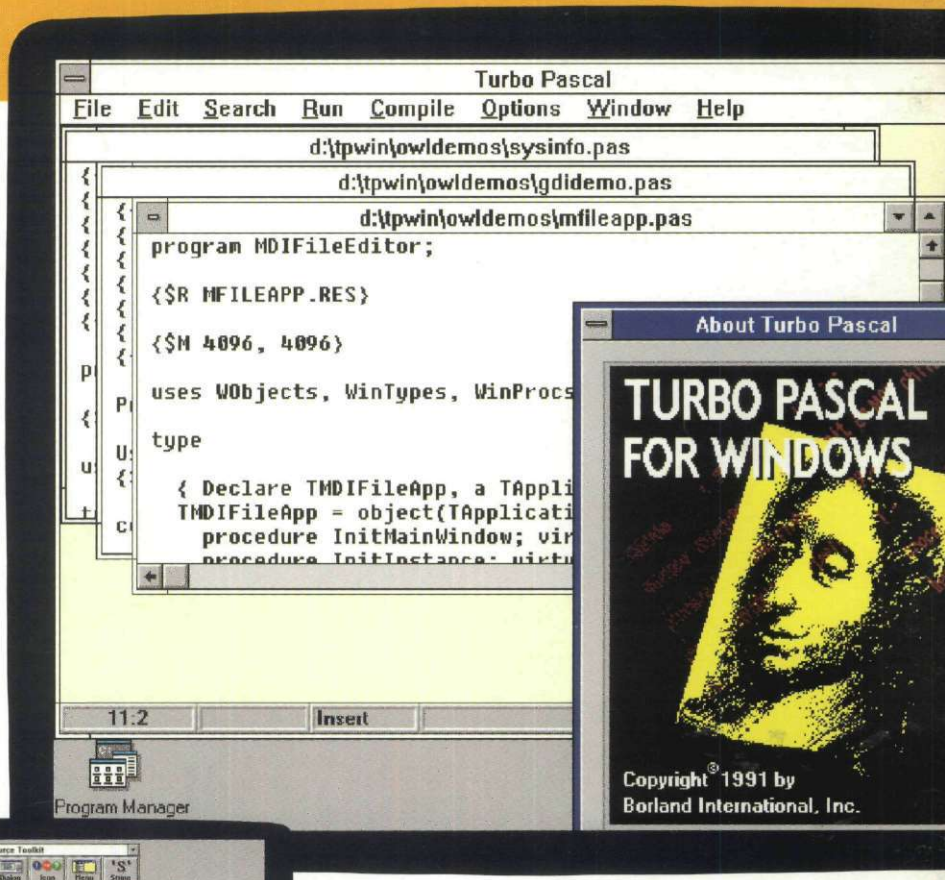

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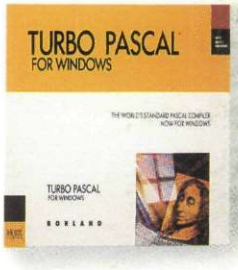

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